Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 880
Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

Washington, D. C. ▼ September 10, 1920

# EFFECTS OF PORK-CURING PROCESSES ON TRICHINÆ

By

B. H. RANSOM, Chief, Zoological Division
B. SCHWARTZ, Assistant Zoologist, and
H. B. RAFFENSBERGER, Veterinary Inspector

## CONTENTS

| | Page |
|---|---|
| The Federal Meat-Inspection Regulations Concerning Trichinæ in Pork | 1 |
| Review of Work of Other Investigators | 2 |
| The Experimental Work | 4 |
| Appearance of Decapsuled Larvæ from Salted Pork | 34 |
| Summary | 35 |
| References to Literature Cited | 37 |

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

UNITED STATES DEPARTMENT OF AGRICULTURE

**BULLETIN No. 880**

Contribution from the Bureau of Animal industry
JOHN R. MOHLER, Chief

Washington, D. C. PROFESSIONAL PAPER September 10, 1920

# EFFECTS OF PORK-CURING PROCESSES ON TRICHINÆ

By B. H. RANSOM, *Chief, Zoological Division;* B. SCHWARTZ, *Assistant Zoologist;* and H. B. RAFFENSPERGER, *Veterinary Inspector.*

## CONTENTS.

| | Page. |
|---|---|
| The Federal meat-inspection regulations concerning trichinæ in pork | 1 |
| Review of work of other investigators | 2 |
| The experimental work | 4 |
| Methods of investigation | 4 |
| Experiments with various kinds of sausage | 7 |
| Dried summer sausage | 7 |
| Dried summer sausage (supplementary) | 10 |
| Pepperoni | 11 |
| Smoked summer sausage | 12 |
| Pickled summer sausage | 14 |
| Sausages smoked at temperatures of about 100° F | 15 |
| The experimental work—Continued. | |
| Sausage smoked at temperatures of about 125° to 130° F | 16 |
| Experiments with Italian style hams | 22 |
| Experiments with capicola | 26 |
| Experiments with coppa | 29 |
| Experiments with lockschinken | 30 |
| Influence of salt on the resistance of trichina larvæ to heat | 32 |
| Appearance of decapsuled larvæ from salted pork | 34 |
| Summary | 35 |
| References to literature cited | 37 |

## THE FEDERAL MEAT-INSPECTION REGULATIONS CONCERNING TRICHINÆ IN PORK.

Prior to the investigations recorded in this paper comparatively little was known concerning the effects of processes used in curing pork upon the vitality of trichinæ (*Trichinella spiralis*). From a practical standpoint information on this subject is of considerable importance, particularly in the case of pork products of kinds customarily eaten without cooking. Hygienically the custom of eating uncooked pork is very objectionable and is not to be encouraged. Nevertheless, the fact of its existence must be reckoned with, and in Federal meat inspection it has been necessary to give consideration to the question of safeguarding the consumer from the danger of acquiring trichinosis from pork products of kinds customarily eaten without cooking.

It has been assumed as governing principles that the consumer is himself responsible for the proper preparation of fresh pork and pork products of kinds that are usually cooked before eating, but that the manufacturer is under obligations to make sure that pork products sold as cooked products are properly cooked or, if of a kind customarily eaten without cooking, to make sure that the products are free from viable trichinæ. In the Federal meat-inspection regulations it is therefore provided that products that are cooked in establishments under inspection must be cooked in accordance with methods approved by the chief of the Bureau of Animal Industry, and further that products containing any raw muscle tissue of pork, if of a kind prepared customarily to be eaten uncooked, must either be subjected to sufficient heat to destroy the vitality of any trichinæ or be subjected to other processes sufficient to destroy the vitality of trichinæ.

The questions of the destruction of the vitality of trichinæ by refrigeration and by heat have been discussed in other papers (Ransom, 1916; Ransom and Schwartz, 1919). It is the purpose of the present paper to record the results of investigations relative to the effects upon the vitality of trichinæ of various methods of preparing pork products of kinds customarily eaten without cooking. Though these results have not heretofore been published in detail, they have already been utilized in the formulation of methods for the preparation of pork products of kinds customarily eaten without cooking. Such products may be prepared in establishments operating under Federal inspection only in accordance with approved methods. Details of these methods are given in Service and Regulatory Announcements of the Bureau of Animal Industry No. 128, December, 1917, page 131; No. 135, June, 1918, page 54; No. 143, March, 1919, page 19, and No. 151, November, 1919, page 121.

## REVIEW OF THE WORK OF OTHER INVESTIGATORS.

In the extensive literature on trichinæ the effects of salting and smoking upon the encysted parasites are frequently referred to, but only a few investigators have actually carried on experimental work, most of the references in the literature consisting of repetitions of the statements made by these investigators. In addition to statements based on the results of experimental work, other statements are commonly made that have no apparent basis except the opinions of the writers that made them, or of other writers whom they have quoted, and these are often more or less at variance with the facts. The important contributions to our knowledge of the effects of curing processes upon trichinæ so far as heretofore published may be covered in a comparatively brief summary.

Haubner, Leisering, and Küchenmeister (1863) concluded that 24 hours of hot smoking rendered sausage made of trichinous pork innocuous, since two rabbits to which the sausage was fed did not become infected. These investigators also found that cold smoking for a period of three days did not destroy the vitality of trichinæ. No record of the temperatures attained in the hot and cold smoking is given.

Haubner (1864) states that cold smoking at a temperature of 30° R. (37.5° C.) or less is not effective in destroying trichinæ. He also states that smoking at a temperature of 52° R. (65° C.) or higher either promptly kills the parasites or so enfeebles them that they soon die. This writer notes further that a few days' salting will not kill trichinæ in meat, but that pickling of several weeks' duration apparently kills encysted trichinæ.

According to Fürstenberg (1864), proper pickling of trichinous meat with salt results in the destruction of the parasites after a period of 10 days. Fürstenberg also concluded that salting followed by a few days' smoking at a low temperature and finally by a period of drying of 8 or 9 days' duration rendered sausage innocuous. He observed that trichinæ from salted pork are shrunken and states that salt exerts a desiccating action on the parasites.

Virchow (1866) states that according to information furnished him by a sausage manufacturer pickled pork which is subjected to low-temperature smoking (10°–12° R.=12.5°–16° C.) for three days no longer contains viable trichinæ.

According to Leuckart (1876), trichinous meat becomes innocuous if kept in contact with salt for a period of four weeks. He further states that the parasites in such meat are wrinkled. He attributes this to the osmotic action of the salt which brings about the withdrawal of water from the tissues of the parasites.

Colin (1882) found that after a 12-day immersion in 25 per cent salt brine trichinous meat was still infective. Beginning with the fifteenth day he found the parasites dead in the superficial layer of the meat. At the end of the second month they were dead in the central part of the meat. This investigator also tested the effects of salt on minced meat containing encysted trichinæ, and found that 2 per cent salt, acting for a period of 2 weeks, destroyed the vitality of the parasites. He also used larger percentages of salt with similar results. Colin tested the dry-salt treatment on large pieces of meat and concluded that 6 weeks were necessary to insure the destruction of the parasites.

Fourment (1882) records the following experiment:

In March, 1881, he placed some salted pork of American origin in a bottle to which he added enough salt to cover the meat. The bottle was opened 12 months later and the meat was fed to mice. Three days after feeding one mouse died and an examination of its intestinal contents revealed the presence of sexually mature trichinæ. The second mouse, which died 13 days after feeding, also harbored many intestinal trichinæ. Fourment states that making due allowance for the period which elapsed between the salting of the pork and its arrival in France, it is safe to conclude that 15 months of salt action is inadequate to destroy the vitality of encysted trichinæ. In the opinion of the present writers the results of Fourment's experiment and his conclusion are so much at variance with the facts as other investigators have found them that his statements can not be accepted as proved by the evidence presented.

According to Blanchard (1888), Benecke found trichinæ alive in a ham and in a sausage which were kept in brine for 12 days and afterwards smoked. The examination for trichinæ was made 4 and 9 months, respectively, after the above treatments.

According to Stiles (1898), the parasites in trichinous pork are killed if the pork is kept four months in "pickling vats."

## THE EXPERIMENTAL WORK.

### METHODS OF INVESTIGATION.

Most of our investigational work was carried out in cooperation with certain meat-packing establishments in Chicago, which not only furnished the necessary facilities for the work but rendered useful assistance in many other ways. In arranging our investigations we selected methods of preparing the various kinds of products, customarily eaten without cooking, from among the methods in common use that seemed most likely to prove efficacious in destroying the vitality of trichinæ, and also devised other methods that seemed likely to be efficacious in destroying trichinæ and at the same time suited to practical requirements as to manufacture and commercial qualities of the product. These methods were tested by preparing from trichinous pork some of the products in question under the actual conditions of manufacture and then feeding the finished product to experiment animals to determine whether or not the trichinæ survived. Detailed records were kept of each step in the process of preparation, and each lot of product subjected to experiment was held under close supervision by employees of the bureau from the beginning to the end of the experiment.

At first the pork used in the experiments was obtained from the carcasses of naturally infested hogs, carcasses being selected for use only if they showed at least a moderate degree of infestation. This involved the examination of many hundreds of carcasses, and proved unsatisfactory not only on this account but also because heavy infestations were extremely rare in small hogs. In the case of so-called Italian hams, which are usually obtained from rather small carcasses, this fact was of special importance. In order, therefore, to insure an adequate supply of trichinous carcasses of proper sizes for the experiments, the plan was finally adopted of artificially infecting hogs by feeding them trichinous pork. These animals were killed a month to six months after feeding and the meat from their carcasses used in making sausages, hams, and other products. The viability of the trichinæ in each carcass was tested by feeding some of the uncured meat to experimental animals. The uncured meat was kept in a refrigerator and was usually not tested for the presence of viable trichinæ until the close of the experiments on the products made from the remainder of the carcass. In some cases this special test of viability was not necessary because the trichinæ in the products made from the respective carcasses were found to have survived the processes to which the products were subjected in their preparation. In all cases the trichinæ in the uncured meat from carcasses used in the experiments were found to be alive and capable of producing heavy infestations in rats or other experimental animals, so there is no question as to the infectivity of the meat used in making the experimental products.

The usual method of testing the viability of the trichinæ in the cured products was to take portions of some of the pieces of the finished product and feed them to rats or mice in the laboratory of the establishment in which the experimental product was prepared, generally feeding the animals during a period of six or seven days in succession with all of the sausage, ham, or other product they would eat. At the first feeding the unwashed product was fed, but the feedings on the following days were made with some of the product which at the termination of the curing or drying process was ground up in a meat chopper and thoroughly washed with water to remove the salt. In this way further action of the salt in the product was promptly stopped at the close of the experiment. At least three rats or mice were thus fed in each experiment, and commonly two or three lots of rats and mice were fed, using different pieces of the same experimental product for the different lots of animals.

The post-mortem examinations of all the test rats and mice fed in Chicago were made by one of the writers (Raffensperger) or in his presence by members of the laboratory staffs of the meat-packing establishments in which the experimental products were prepared. In some cases test animals were fed not only at the establishment laboratories but also at the Chicago laboratory of the bureau, and in nearly all cases test animals were also fed at the Washington laboratory, some of the pieces of the product from each experiment being shipped to Washington for the purpose.

In many of the experiments there was also shipped to Washington for testing some of the product that had been ground up and washed to stop further salt action. The procedure followed in the Washington laboratory consisted in taking portions from the several pieces of product belonging to a single experiment as soon as possible after they were received from Chicago, grinding them up together in a meat chopper, and washing for about two hours in running water. The ground meat was then fed to three or four rats or mice (usually rats) kept together in a single cage, an average of 10 grams of meat being supplied to each animal at each feeding, and three feedings being given on successive days. In a very few cases guinea pigs were used as test animals, the meat being given by forced feeding.

As may be expected, and as was found by the results of the post-mortem examinations, the plan of feeding several animals together in a single cage does not necessarily bring about an even distribution of the meat among them. Differences in the total quantities of meat eaten by the several animals, however, tend to diminish with successive feedings. All the test animals used in Washington were reared under conditions which practically excluded prior infections with trichinæ as they were bred at the Bureau Experiment Station and until used in the tests were nourished on a diet from which meat was excluded.

Unless they died earlier, the test animals were chloroformed about 30 days after the first feeding of the meat under test, and a portion of the diaphragm and sometimes other muscles were compressed between thick glass slides and examined microscopically to determine the presence or absence of trichinæ. Animals that died from infection with trichinæ or from other causes within 10 days after the first feeding were examined to determine the presence or absence of intestinal trichinæ. If death occurred between the tenth and fifteenth days after the first feeding portions of the diaphragm as well as the intestines were examined. Animals that died after that period were not as a rule examined for intestinal trichinæ, examination being restricted to the musculature. Migrating larvæ that have not yet become encysted or established in the muscles may commonly be detected in the fluid which collects around the muscle as a result of compression between the glass slides, and older but still unencysted larvæ may be seen both in the muscles and in the fluid surrounding the muscles. Intestinal trichinæ when present may be readily demonstrated by slitting open the intestine from end to end after removal of that organ to a Petri dish containing physiological salt solution. Scraping the intestinal mucosa with the dull edge of a scalpel tends to remove firmly adhering parasites. The parasites if present may be picked out of the dish with the aid of a lens, mounted on glass slides and examined microscopically for confirmation of their identity.

The same technic as to post-mortem examinations of test animals was followed in the Chicago laboratories as in the Washington laboratory.

### EXPERIMENTS WITH VARIOUS KINDS OF SAUSAGE.

In the experiments with sausage, fresh summer sausage, unsmoked dried summer sausage, and sausage which was smoked and dried were used. The experiments with each variety of sausage will be discussed separately.

So far as concerns the preliminary preparation of the experimental sausage, the same general method was employed throughout. Trimmings from one or more trichinous hogs were chopped up, usually with some beef trimmings, as in the routine manufacture of sausage, and mixed with the curing and flavoring materials commonly employed in meat-packing establishments, namely, salt, pepper, sodium or potassium nitrate, sugar, coriander seed, etc., in the customary proportions. Of the various materials in the curing mixtures commonly used, salt is the only one of any importance so far as the destruction of trichinæ is concerned. The quantity of salt used in the curing mixtures was computed on the basis of 3⅓ pounds of salt per hundredweight of meat.

Following the addition of the curing mixture the meat was placed in a cooler for a few days. The meat was then stuffed in casings and as a rule was either replaced in the cooler or put into the so-called green room for a short period before being subjected to further treatments, such as drying or smoking, as noted in the discussion of the experiments with various classes of these products.

#### DRIED SUMMER SAUSAGE.

In the experiments with dried summer sausage, after the preliminary curing process in the cooler and green room the sausage was kept in the drying room for a period of about 20 days. Forty-one experiments were carried out at Establishments 2A and 3, the meat used being trimmings from 76 trichinous hogs. These experiments were supplemented by others with dried sausage made in the laboratory. The latter experiments are discussed elsewhere in this paper.

Several sausages were prepared for each experiment. These ranged in weight from 8 ounces to 2½ pounds as freshly stuffed products. As a result of the prolonged period of drying the sausages underwent considerable shrinkage, varying from 20 to 40 per cent of the green weight.

The records of the experiments follow in Tables 1 and 2.

TABLE 1.—*Experiments with dried sausage.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. |  |  |  |  |  | Drying. |  |  | Total time under supervision. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Time in cooler. | Temperature. |  | Time in green room. | Temperature. |  | Time in dry room. | Temperature. |  |  |  |
|  |  |  | Maximum. | Minimum. |  | Maximum. | Minimum. |  | Maximum. | Minimum. |  |  |
|  | *Hog.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Days.* |  |
| 1 | 1 and 2.... | 3 | 42 | 38 | ...... | ...... | ...... | 19 | 65 | 54 | 22 | Negative. |
| 2 | 3 and 4.... | $3\frac{1}{3}$ | 43 | 36 | $1\frac{2}{3}$ | 66 | 62 | 20 | 70.5 | 47.5 | 25 | Do. |
| 3 | 5 and 6.... | $1\frac{5}{6}$ | 38 | 34.5 | $1\frac{1}{6}$ | 65 | 61 | 20 | 70.5 | 47.5 | 23 | Do. |
| 4 | 7 and 8.... | 3 | 36.5 | 33.5 | 2 | 63 | 59.5 | 20 | 59 | 46 | 25 | Do. |
| 5 | 9, 10, 11... | 3 | 39.5 | 36 | $3\frac{2}{3}$ | 62 | 59 | 21 | 60 | 43 | $27\frac{2}{3}$ | Do. |
| 6 | 12......... | 2 | 38.5 | 34.5 | 2 | 60 | 56 | 19 | 55 | 46 | 23 | Do. |
| 7 | 13 and 14.. | 3 | 40 | 34 | $1\frac{1}{6}$ | 59 | 58 | 21 | 56 | 47 | $25\frac{1}{6}$ | Do. |
| 8 | 15......... | 3 | 43 | 42 | $2\frac{5}{6}$ | 61 | 60 | 20 | 68 | 45 | $25\frac{5}{6}$ | Do. |
| 9 | 16 and 17.. | 3 | 46 | 42 | $1\frac{1}{3}$ | 62 | 56 | 20 | 68 | 46 | $24\frac{1}{3}$ | Do. |
| 10 | 18......... | $2\frac{11}{12}$ | 48 | 42 | $1\frac{2}{3}$ | 66 | 63 | 21 | 77.5 | 47 | $25\frac{7}{12}$ | Do. |
| 11 | 19 and 20.. | 4 | 53 | 47 | $1\frac{3}{4}$ | 78 | 50 | 20 | 56 | 50 | $25\frac{3}{4}$ | Do. |
| 12 | 21 and 22.. | 4 | 43 | 40 | $1\frac{5}{6}$ | 69 | 65 | 20 | 58 | 50 | $25\frac{5}{6}$ | Do. |
| 13 | 24 and 25.. | 4 | 46 | 43 | $1\frac{5}{6}$ | 65 | 58 | 19 | 64 | 49 | $24\frac{5}{6}$ | Do. |
| 14 | 26 and 27.. | 4 | 44 | 38 | $1\frac{3}{4}$ | 63 | 54 | 19 | 61 | 47 | $24\frac{3}{4}$ | Do. |
| 15 | 28 and 29.. | 4 | 44 | 37 | $1\frac{3}{4}$ | 59 | 58 | 20 | 53 | 46 | $25\frac{3}{4}$ | Do. |
| 16 | 30 and 31.. | 4 | 46 | 43 | $1\frac{5}{6}$ | 63 | 55 | 19 | 52 | 47 | $24\frac{5}{6}$ | Do. |
| 17 | 32 and 33.. | 5 | 48 | 44 | $\frac{5}{6}$ | 60 | 60 | 20 | 57 | 45 | $25\frac{5}{6}$ | Do. |
| 18 | 34 and 35.. | 5 | 45 | 43 | 1 | 48 | 46 | 21 | 52 | 46 | 27 | Do. |
| 19 | 36 and 37.. | 4 | 43 | 40 | $2\frac{3}{4}$ | 80 | 54 | 21 | 80 | 52 | $27\frac{3}{4}$ | Do. |
| 20 | 38 and 39.. | 4 | 49 | 42 | $1\frac{19}{24}$ | 65 | 61 | 21 | 67 | 45 | $26\frac{19}{24}$ | Do. |

TABLE 2.—*Experiments with dried sausage.*

(ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Preliminary curing. |  |  |  |  |  | Drying. |  |  | Total time under supervision. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Time in cooler. | Temperature. |  | Time in green room. | Temperature. |  | Time in dry room. | Temperature. |  |  |  |
|  |  |  | Maximum. | Minimum. |  | Maximum. | Minimum. |  | Maximum. | Minimum. |  |  |
|  | *Hog.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Days.* |  |
| 21 | 1, 2, 3..... | 5 | 39 | 36 | ...... | ...... | ...... | 20 | 72 | 54 | 25 | Negative. |
| 22 | 4, 5, 6..... | 6 | 40 | 36 | ...... | ...... | ...... | 19 | 68 | 56 | 25 | (1) |
| 23 | 7 and 8.... | 7 | 40 | 33 | ...... | ...... | ...... | 20 | 64 | 53 | 27 | Negative. |
| 24 | 9 and 10... | 3 | 36 | 34 | ...... | ...... | ...... | 19 | 65 | 53 | 22 | Do. |
| 25 | 11......... | 3 | 38 | 35 | ...... | ...... | ...... | 20 | 60 | 50 | 23 | Do. |
| 26 | 12 and 13.. | 3 | 36 | 33 | ...... | ...... | ...... | 19 | 60 | 52 | 22 | Do. |
| 27 | 14 and 15.. | $1\frac{5}{6}$ | 39 | 35 | ...... | ...... | ...... | 20 | 64 | 54 | $21\frac{5}{6}$ | Do. |
| 28 | 16 and 17.. | 3 | 41 | 37 | 2 | 71 | 67 | 21 | 62 | 54 | 26 | Do. |
| 29 | 18 and 19.. | 3 | 41 | 35 | 2 | 70 | 62 | 19 | 66 | 53 | 24 | Do. |
| 30 | 20 and 21.. | 3 | 43 | 40 | 2 | 70 | 66 | 20 | 71 | 59 | 25 | Do. |
| 31 | 22 and 23.. | 3 | 46 | 37 | 2 | 86 | 79 | 19 | 86 | 62 | 24 | Do. |
| 32 | 24 and 25.. | 4 | 42 | 36 | $\frac{3}{4}$ | 77 | 62 | 19 | 73 | 51 | $23\frac{3}{4}$ | Do. |
| 33 | 26 and 27.. | 3 | 40 | 33 | 1 | 69 | 63 | 18 | 65 | 56 | 22 | Do. |
| 34 | 28 and 29.. | 4 | 42 | 35 | $1\frac{3}{4}$ | 66 | 62 | 20 | 58 | 47 | $25\frac{3}{4}$ | Do. |
| 35 | 30......... | 4 | 42 | 37 | $1\frac{1}{4}$ | 65 | 59 | 19 | 59 | 46 | $24\frac{1}{4}$ | Do. |
| 36 | 31......... | 1 | 41 | 38 | $1\frac{5}{6}$ | 67 | 58 | 19 | 60 | 51 | $21\frac{5}{6}$ | Do. |
| 37 | 32 and 33.. | 3 | 46 | 39 | $1\frac{5}{6}$ | 66 | 62 | 17 | 64 | 51 | $21\frac{5}{6}$ | Do. |
| 38 | 34......... | 4 | 42 | 36 | $1\frac{3}{4}$ | 60 | 59 | 18 | 70 | 54 | $23\frac{3}{4}$ | Do. |
| 39 | 35 and 36.. | $4\frac{1}{4}$ | 40 | 35 | $1\frac{5}{6}$ | 70 | 62 | 18 | 73 | 61 | $24\frac{1}{12}$ | Do. |
| 40 | 37......... | 4 | 43 | 37 | 2 | 77 | 72 | 19 | 78 | 60 | 25 | Do. |
| 41 | 38......... | 3 | 40 | 37 | 2 | 71 | 60 | 17 | 68 | 53 | 22 | Do. |

---

[1] Negative at Chicago and positive at Washington—1 of 4 rats fed in Washington showed 4 encysted larvæ in the diaphragm, other 3 free from trichinæ.

An examination of the data presented in the foregoing tables shows that the time in the cooler varied from 1 to 7 days, that the time in the green room varied from 0 to $3\frac{2}{3}$ days, that the time in the drying room varied from 17 to 21 days, and that the total period during which the sausage was held after the salt was added to the meat varied from 22 to 28 days. Inasmuch as trichinæ survive in uncured meat much longer than 28 days, it may be concluded that the salting and drying of the sausage as practiced in these experiments were destructive to the trichinæ. The destruction of the parasites may not be ascribed entirely to the action of the salt, since drying enters as a complicating factor. It is quite evident, however, that the combination of salting and drying during periods ranging from 22 to 28 days destroyed the vitality of the trichinæ and that infested sausage after such treatment became incapable of producing trichinosis, with the possible exception of the sausage in Experiment 22.

The sausage in Experiment 22 (Table 2) was fed to four rats at the laboratory in Washington, and on post-mortem examination one of the rats was found very slightly infested with trichinæ, the other three being free from parasites. Three rats fed at the laboratory of Establishment 2A, however, escaped infection. The sausage after stuffing was kept in the cooler for 6 days, then transferred to the drying room, where it was kept for 19 days. The first feeding of test animals at the Washington laboratory was given 2 days after the sausage was taken out of the drying room, so that a total period of 27 days had elapsed from the time the salt was added to the meat before the vitality of the trichinæ was tested at Washington, or 2 days later than the Chicago test. It is by no means improbable, however, that the infection was extraneous, as a result of insufficient care on the part of the attendant in cleaning the cages and in feeding and watering the animals, thereby contaminating the food or water of the rats with material from other cages, some of which contained rats which had been fed trichinous meat. But even if the possibility of extraneous infection should be left out of consideration the infection which was produced was so light as to be practically negligible. The post-mortem examination revealed but four encysted trichinæ in the entire diaphragm, which is known to be a favorite location of these parasites. Three other rats fed some of the same sausage for several days in succession at Washington and three similarly fed at Chicago escaped infection entirely. It may be noted in this connection that the sausage in question was made from pork trimmings of three well-infected hogs and that no beef trimmings were added to the pork. Thus the conditions were decidedly favorable to the production of heavy infections, even if only a small percentage of the larvæ survived the curing and drying processes. The pork trimmings used in a given lot of sausage that is prepared for the trade usually come from a large number of different hogs and are mixed with beef trimmings. This tends to dilute the trichina infection, inasmuch as only a very small percentage of carcasses from which the pork trimmings are obtained are likely to be infested (less than 2 per cent).

In view of these facts and of the negative results obtained in the remaining 40 experiments, a method of preparing dried sausage customarily eaten without cooking in which the sausage is dried for at least 20 days following a preliminary curing period (in cooler and green room) has been approved by the bureau with the provision that the product must be held under supervision for a total period of at least 25 days from the time the salt is added to the meat, thus allowing either a preliminary curing period of 5 days or a correspondingly longer drying period if the preliminary curing period is reduced to less than 5 days.

### DRIED SUMMER SAUSAGE (SUPPLEMENTARY).

In connection with certain experiments performed at Establishment 537, relating to pickled summer sausage, the following experiments were made with reference to a 20-day drying period following a preliminary curing period:

*Experiment 42.*—Pork trimmings from two trichinous hogs were chopped up with equal quantities of beef trimmings, to which was added a dry-curing mixture containing but a small quantity of salt. Following the stuffing of the meat in casings, the sausage was placed in a 70° (salometer strength) pickle and kept in this pickle for 3½ days at a temperature ranging between 36° and 38° F. The sausage was then placed in the drying room for 20 days at a temperature ranging from 48° to 55° F. Animals fed with this sausage failed to become infected.

*Experiment 43.*—Another lot of sausage prepared as in Experiment 42, kept in pickle for 3 days, and then dried for 20 days, also failed to produce infection.

The experiments described below were performed in the laboratory of the Zoological Division at Washington.

Six and one-quarter pounds of pork trimmings obtained from seven trichinous hogs were chopped up with 1¼ pounds of beef trimmings, to which was added a dry-curing mixture containing 4 ounces of common salt. After the addition of the curing mixture the meat was held for 2 days in a cooler at a temperature ranging from 35° to 38° F. It was then taken out of the cooler, part of it was stuffed in casings, and the remainder placed in a tin can, which was closed with a tightly fitting lid. Five stuffed sausages and the can of unstuffed meat were then placed in a refrigerator kept at a temperature ranging between 45° and 49.5° F. and held for various periods as follows:

*Experiment 44.*—One of the sausages was held in the refrigerator for 3 days. A portion of the meat was then digested in an acidified solution of scale pepsin and 279 decapsuled larvæ were examined microscopically. Of these 170 were active, mostly sluggish, though some were rather lively. Five rats which were fed portions of the sausage became heavily infested.

*Experiment 45.*—Another sausage was held in the refrigerator for 8 days and 280 decapsuled larvæ isolated from a portion of the sausage by artificial digestion were examined and 91 were found active, mostly sluggish, though a few were fairly lively. Five rats fed on this sausage became heavily infested.

*Experiment 46.*—This sausage was held in the refrigerator for 14 days. An examination of 319 decapsuled larvæ showed them to be inactive, pale in appearance, and uncoiled. Five rats to which this sausage was fed escaped infection.

*Experiment 48.*—This sausage was held in the refrigerator for 15 days; 194 decapsuled larvæ were examined and found to be pale in color, inactive, and uncoiled. Of 5 rats to which this meat was fed, 2 became heavily infested, the other 3 escaping infection.

*Experiment 49.*—This sausage was held in the refrigerator for 16 days. A microscopic examination of 219 decapsuled larvæ showed them to be inactive. Five rats fed on this meat escaped infection.

*Experiment 50.*—The unstuffed meat kept in a closed can was held in the refrigerator for 16 days. An examination of 141 decapsuled larvæ was made, of which 17 were found to be active; some were rather sluggish. Five rats fed on portions of this meat became infested, the degree of infestation varying from light to moderate.

The results of Experiment 50 are significant, as they indicate that evaporation of moisture is a factor of decided importance in the destruction of trichinæ in salted meat, evidently through increased salt concentration as a result of the loss of water. The stuffed sausages in Experiments 48 and 49 lost 24 per cent and 19 per cent of their respective weights and yielded upon analysis a salt content of 4.15 per cent and 3.9 per cent, respectively, whereas the unstuffed meat lost no weight from evaporation and its salt content was 3.3 per cent.

### PEPPERONI.

The name pepperoni is applied to unsmoked dried summer sausage which is stuffed in thin and narrow sheep or hog casings, a special curing mixture being used to give this product its characteristic flavor.

Thirteen experiments with this variety of sausage were carried out at Establishment 3. The same quantity of salt in proportion to the quantity of meat was used in this sausage as in the other experiments, namely, 3⅓ pounds per hundredweight. In this series pork trimmings from 19 trichinous hogs were used. About 6 sausages were used in each experiment, ranging in weight from 14 ounces to 1½ pounds. Owing to the thin and slender casings in which the meat was stuffed, the shrinkage was considerably greater than in the case of larger dried sausages; it averaged about 40 per cent of the weight of the freshly stuffed sausages. Because of the small size of pepperoni and their more rapid drying it was expected that a shorter period of drying than that found necessary in the case of larger sausages would be found sufficient to destroy the vitality of the trichinæ, and this expectation was realized. The records of the tests with pepperoni are given in Table 3.

TABLE 3.—*Experiments with pepperoni sausage.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Drying. | | | Total time under supervision. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time in dry room. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Days.* | |
| 51 | 9 and 10.. | 3 | 36 | 34 | 2 | 65 | 54 | 13 | 59 | 48 | 18 | Negative. |
| 52 | 26 and 27.. | 3 | 40 | 33 | 1 | 69 | 63 | 13 | 62 | 56 | 17 | Do. |
| 53 | 28 and 29.. | 4 | 42 | 35 | 1¼ | 66 | 62 | 14 | 63 | 52 | 19 | Do. |
| 54 | 30.......... | 4 | 42 | 37 | 1¼ | 65 | 59 | 14 | 59 | 46 | 19 | Do. |
| 55 | 31.......... | 1 | 41 | 38 | 1⅚ | 67 | 58 | 13 | 59 | 51 | 17 | Do. |
| 56 | 32 and 33.. | 3 | 46 | 39 | 1⅚ | 66 | 62 | 12 | 64 | 51 | 17 | Do. |
| 57 | 34.......... | 4 | 42 | 36 | 1⅚ | 60 | 59 | 12 | 60 | 54 | 19 | Do. |
| 58 | 35 and 36.. | 4¼ | 40 | 35 | 1⅚ | 70 | 62 | 12 | 72 | 60 | 18 | Do. |
| 59 | 37.......... | 4 | 43 | 37 | 1⅚ | 77 | 72 | 11 | 75 | 60 | 17 | Do. |
| 60 | 38.......... | 3 | 40 | 37 | 2 | 71 | 60 | 12 | 68 | 53 | 17 | Do. |
| 61 | 39.......... | 2⅔ | 39 | 37 | 1⅔ | 65 | 61 | 12 | 60 | 56 | 16 | Do. |
| 62 | 40.......... | 2 | 42 | 38 | 1⅔ | 61 | 52 | 13 | 58 | 53 | 17 | Do. |
| 63 | 41 and 42.. | 3 | 40 | 36 | 3 | 62 | 58 | 11 | 58 | 53 | 17 | Do. |

The data presented in Table 3 show that the total period during which these sausages were held before testing after the curing materials were added varied from 16 to 19 days. During that period the sausage after stuffing was kept in the drying room from 11 to 14 days. Inasmuch as the results of the feeding of experimental animals were consistently negative, a shorter period of drying pepperoni than that required in the case of larger sausages has been permitted by the bureau. The regulations with reference to those products specify drying for at least 15 days at a temperature not lower than 45° F., and a total period of not less than 20 days during which the sausage must be held after the salt has been added to the meat.

### SMOKED SUMMER SAUSAGE.

In the experiments described below the sausage was dried for periods of 10 days or less. To compensate for the reduced drying period the products were smoked at a low temperature for about 40 hours prior to drying.

Thirty experiments carried out in Establishments 2A and 3 are summarized in Tables 4 and 5. The sausage used in these experiments was made from trimmings from 49 different hogs. The weights of the green sausages, of which about 6 were used in each experiment, ranged from 10 ounces to 3¾ pounds, averaging about 2 pounds. The shrinkage of the sausages from loss of moisture varied from about 20 to 40 per cent, depending upon their size.

### TABLE 4.—*Experiments with smoked dry summer sausage.*

(ESTABLISHMENT 2A).

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Total time under supervision. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in dry room before smoking. | Temperature. | | Time in smoke room. | Temperature. | | Time in dry room after smoking. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Days.* | |
| 64 | 9 and 10 | 3 | 36 | 34 | ⅚ | 65 | 63 | 40 | 76 | 61 | 2⅚ | 58 | 55 | 9 | Negative. |
| 65 | 11 | 5 | 38 | 35 | ...... | ...... | ...... | 40 | 80 | 51 | 10 | 57 | 50 | 17 | Do. |
| 66 | 12 and 13 | 4 | 40 | 33 | ...... | ...... | ...... | 40 | 89 | 73 | 8 | 58 | 49 | 14 | (1) |
| 67 | 14 and 15 | 2¾ | 41 | 35 | ...... | ...... | ...... | 41 | 83 | 64 | 10 | 64 | 55 | 15 | Negative. |
| 68 | 16 and 17 | 4 | 41 | 37 | ...... | ...... | ...... | 40 | 87 | 79 | 10 | 62 | 53 | 16 | Do. |
| 69 | 18 and 19 | 4 | 44 | 35 | ...... | ...... | ...... | 40 | 85 | 67 | 11 | 66 | 55 | 17 | Do. |
| 70 | 20 and 21 | 5 | 43 | 37 | ...... | ...... | ...... | 40 | 98 | 80 | 10 | 71 | 59 | 17 | Do. |
| 71 | 22 and 23 | 4 | 46 | 37 | ...... | ...... | ...... | 36 | 98 | 84 | 11 | 86 | 71 | 16½ | Do. |
| 72 | 24 and 25 | 5⅚ | 45 | 36 | ...... | ...... | ...... | 39½ | 90 | 80 | 10 | 63 | 51 | 18 | Do. |
| 73 | 4, 5, 6 | 6 | 40 | 36 | 1 | ...... | ...... | 29½ | 98 | 62 | 9 | 65 | 56 | 17 | Do. |
| 74 | 16 and 17 | 3 | 41 | 37 | 2 | 71 | 67 | 24½ | 98 | 81 | 9 | 58 | 53 | 15 | Do. |
| 75 | 18 and 19 | 3 | 41 | 35 | 2 | 70 | 62 | 23 | 97 | 81 | 11 | 66 | 55 | 17 | Do. |
| 76 | 20 and 21 | 3 | 43 | 40 | 2 | 72 | 65 | 23 | 100 | 80 | 11 | 71 | 59 | 17 | Do. |
| 77 | 26 and 27 | 3 | 40 | 33 | 1 | 69 | 63 | 40 | 94 | 82 | 11 | 65 | 56 | 17 | Do. |
| 78 | 28 and 29 | 5⅙ | 39 | 35 | ...... | ...... | ...... | 40 | 94 | 84 | 10 | 59 | 50 | 17 | Do. |
| 79 | 30 | 4 | 42 | 37 | 1¼[2] | 65 | 59 | 40 | 89 | 80 | 10 | 58 | 50 | 17 | Do. |
| 80 | 31 | 1 | 41 | 38 | 1 | 67 | 58 | 40 | 88 | 81 | 11 | 59 | 51 | 15 | Do. |
| 81 | 32 and 33 | 3 | 46 | 39 | 1⅝ | 66 | 62 | 40 | 92 | 84 | 10 | 64 | 51 | 17 | Do. |
| 82 | 34 | 4 | 42 | 36 | 1⅔ | 65 | 59 | 40 | 88 | 84 | 10 | 60 | 55 | 18 | Do. |
| 83 | 35 and 36 | 4¼ | 40 | 35 | ⅚ | 70 | 68 | 40 | 97 | 78 | 10 | 72 | 60 | 17 | Do. |
| 84 | 37 | 4⅚ | 43 | 37 | ⅚ | 74 | 72 | 40 | 100 | 85 | 10 | 75 | 60 | 18 | Do. |
| 85 | 38 | 3 | 40 | 36 | 1 | 63 | 60 | 40 | 92 | 80 | 9 | 69 | 51 | 15 | Do. |

[1] Positive at Chicago and negative at Washington.

[2] Before smoking, the sausage of this test was held in green room instead of dry room.

### TABLE 5.—*Experiments with smoked dry summer sausage.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Total time under supervision. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time in smoke room. | Temperature. | | Time in dry room. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Days.* | |
| 86 | 24 and 25 | 4 | 46 | 43 | 1⅚ | 65 | 58 | 34 | 85 | 80 | 13 | 62 | 49 | 20½ | Negative. |
| 87 | 26 and 27 | 4 | 44 | 38 | 1¾ | 63 | 54 | 32 | 86 | 74 | 10 | 57 | 49 | 17 | Do. |
| 88 | 28 and 29 | 4 | 44 | 37 | 1¾ | 59 | 58 | 33 | 88 | 70 | 11 | 52 | 45 | 18 | Do. |
| 89 | 30 and 31 | 4 | 46 | 43 | 1⅚ | 63 | 55 | 32 | 86 | 75 | 10 | 51 | 45 | 17 | Do. |
| 90 | 32 and 33 | 5 | 48 | 44 | 1 | 60 | 58 | 35 | 115 | 76 | 11 | 52 | 45 | 18½ | Do. |
| 91 | 34 and 35 | 5 | 45 | 43 | 1 | 48 | 46 | 37 | 95 | 86 | 11 | 52 | 46 | 18½ | Do. |
| 92 | 36 and 37 | 4 | 43 | 40 | 2¾ | 80 | 54 | 38 | 84 | 78 | 10 | 80 | 65 | 18 | Do. |
| 93 | 38 and 39 | 4 | 49 | 42 | 1¾ | 65 | 61 | 40 | 86 | 81 | 10 | 57 | 45 | 17½ | Do. |

The data presented in Tables 4 and 5 show a discrepancy in the results of the feeding tests in only one experiment, namely, Experiment 66, Table 4. Two rats fed at the laboratory of Establishment 2A became infected, whereas 4 rats fed in the laboratory at Washington escaped infection. The difference in time between the first feedings in the two respective laboratories was 5 days, and the salt in the sausage that was forwarded to Washington thus continued to act just so much longer than in the case of the sausage of the same lot that was fed to experimental animals in Chicago. To this factor the above-mentioned discrepancy in the results of the feeding test is probably to be ascribed. From this experiment it may be concluded that a drying period of 8 days following 40 hours of smoking and the usual preliminary curing process is insufficient for the destruction of trichinæ in sausage.

On the basis of the 30 experiments summarized in Tables 4 and 5, the results of which showed that no trichinæ survived, except in Experiment 66 in which the drying period was only 8 days, the following specifications for a method of preparing sausage have been approved by the bureau as meeting the requirements for the destruction of trichinæ. After a certain preliminary curing as specified the sausage must be smoked for not less than 40 hours at a temperature not lower than 80° F., dried for not less than 10 days at a temperature not lower than 45° F., and altogether held under supervision for at least 18 days from the time the salt is added to the meat. These specifications thus allow a period of about 6 days for preliminary curing. If the period of preliminary curing is curtailed below 6 days the products are required to be held for a corresponding period in excess of 10 days in the drying room.

### PICKLED SUMMER SAUSAGE.

A small series of tests with pickled summer sausage prepared at Establishment 537 in a manner similar to that described under Experiment 42 is summarized in Table 6. The products were smoked for about 50 hours, following preliminary curing, and then dried for 10 days, as indicated in the table. Experimental animals fed with this sausage failed to become infected.

TABLE 6.—*Experiments with smoked pickled summer sausage.*

(ESTABLISHMENT 537.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Total time under supervision. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in dry room. | Temperature. | | Time in smoke room. | Temperature. | | Time in dry room. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Hours.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Days.* | |
| 94 | 1 and 2.... | 3 | 36 | 34 | $2\frac{2}{3}$ | 56 | 50 | $52\frac{1}{2}$ | 98 | 70 | 10 | 52 | 46 | 18 | Negative. |
| 95 | 1 and 2.... | $2\frac{5}{6}$ | 38 | 36 | 2 | 52 | 46 | 52 | 100 | 74 | 10 | 50 | 46 | 17 | Do. |
| 96 | 1 and 2.... | 4 | 36 | 34 | 2 | 50 | 48 | 51 | 107 | 72 | 10 | 50 | 46 | 18 | Do. |
| 97 | 3 and 4.... | 3 | 40 | 36 | $2\frac{3}{4}$ | 70 | 68 | 48 | 102 | 70 | 11 | 50 | 48 | 19 | Do. |
| 98 | 3 and 4.... | $3\frac{2}{3}$ | 38 | 36 | $4\frac{1}{6}$ | 54 | 50 | 54 | 101 | 78 | 10 | 55 | 48 | 20 | Do. |

### SAUSAGE SMOKED AT TEMPERATURES OF ABOUT 100° F.

In the experiments described below, the sausage was smoked for six hours at a temperature of about 100° F. following the customary preliminary cure in cooler and green room, and then dried for about 10 days. The records of these experiments, 19 in number, are summarized in Tables 7 and 8. The sausage used was made from pork trimmings from 36 carcasses. The same preliminary curing process was used as in the other experiments. The weights of the individual sausages, about nine of which were used in each experiment, ranged from 8 ounces to 1¾ pounds. The shrinkage of the sausages averaged about 25 per cent.

TABLE 7.—*Experiments with smoked summer sausage.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Total time under supervision, exclusive of smoking. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time in smoke room. | Temperature. | | Time in dry room. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *° F.* | *° F.* | *Days.* | *° F.* | *° F.* | *Hours.* | *° F.* | *° F.* | *Days.* | *° F.* | *° F.* | *Days.* | |
| 99 | 1 and 2 | 3 | 42 | 38 | 2 | 63 | 67 | 6 | 109 | 96 | 10 | 62½ | 54 | 15 | Negative. |
| 100 | 3 and 4 | 2⅓ | 43 | 36 | 1⅔ | 66 | 62 | 6 | 101 | 95 | 10 | 64 | 55 | 15 | Do. |
| 101 | 5 and 6 | 2 | 38 | 34.5 | 2 | 65 | 61 | 6 | 103 | 95 | 10 | 64 | 55 | 14 | Positive. |
| 102 | 7 and 8 | 2¾ | 36.5 | 33.5 | 2 | 63 | 59.5 | 8 | 102 | 95 | 8⅚ | 54 | 46 | 14 | Negative. |
| 103 | 9, 10, 11 | 3⅓ | 39.5 | 36 | 3⅔ | 62 | 59 | 6 | 108 | 95 | 11 | 60 | 47.5 | 18 | Do. |
| 104 | 12 | 2 | 38.5 | 34.5 | 2 | 60 | 56 | 6 | 105 | 95 | 9 | 51 | 46 | 13 | Positive. |
| 105 | 13 and 14 | 3 | 40 | 34 | 1⅚ | 59 | 58 | 6 | 108 | 94 | 15 | 54 | 47 | 20 | Do. |
| 106 | 15 | 3 | 43 | 42 | 3 | 61 | 60 | 7 | 106 | 90 | 10 | 68 | 47 | 16 | Negative. |
| 107 | 16 and 17 | 3 | 46 | 42 | 1⅓ | 62 | 56 | 6 | 104 | 91 | 10 | 67 | 49 | 15 | (1) |
| 108 | 18 | 3 | 48 | 42 | 1⅔ | 66 | 63 | 6 | 106 | 99.5 | 10 | 71 | 55 | 15 | Positive. |
| 109 | 19 and 20 | 4 | 53 | 47 | 1¾ | 78 | 50 | 6 | 102 | 95 | 11 | 89 | 68 | 17 | Negative. |
| 110 | 21 and 22 | 4 | 43 | 10 | 1⅚ | 69 | 65 | 6 | 102 | 71 | 11 | 72 | 52 | 17 | Do. |

[1] Positive at Chicago and negative at Washington.

TABLE 8.—*Experiments with smoked summer sausage.*

(ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Total time under supervision, exclusive of smoking. | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time in smoke room. | Temperature. | | Time in dry room. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *° F.* | *° F.* | *Days.* | *° F.* | *° F.* | *Hours.* | *° F.* | *° F.* | *Days.* | *° F.* | *° F.* | *Days.* | |
| 111 | 1 to 3 | 5 | 39 | 36 | 2 | ..... | ..... | 6 | 96 | 95 | 10 | 67 | 55 | 17 | Negative. |
| 112 | 7 and 8 | 7 | 40 | 33 | 2 | 53 | 52 | 6½ | 100 | 97 | 10 | 61 | 50 | 19 | Do. |
| 113 | 11 | 3 | 38 | 35 | ¾ | 60 | 57 | 6 | 99 | 95 | 10 | 57 | 52 | 14 | Do. |
| 114 | 12 and 13 | 3 | 36 | 33 | ⅔ | 64 | 59 | 6 | 104 | 96 | 9 | 60 | 49 | 13 | Positive. |
| 115 | 14 and 15 | 1⅚ | 39 | 35 | ⅚ | 64 | 60 | 6 | 102 | 93 | 10 | 64 | 53 | 13 | Negative. |
| 116 | 22 and 23 | 3 | 46 | 37 | 1 | 86 | 79 | 10 | 97 | 84 | 13 | 86 | 71 | 17 | Do. |
| 117 | 24 and 25 | 4 | 42 | 36 | ¾ | 77 | 62 | 8 | 97 | 85 | 10 | 68 | 51 | 15 | Do. |

The data presented in Tables 7 and 8 show that the sausage in the 6 experiments that yielded positive results was held for periods ranging from 13 to 20 days, and that the sausage in the 13 experiments that yielded negative results was held for 13 to 19 days. The difference in results is accordingly not to be explained on the basis of differences in the drying period. Evidently the method of smoking sausages for a few hours and then drying for 10 days is not a reliable method for the destruction of trichinæ.

The detailed results of the feeding tests with the sausage that produced infections are as follows:

*Experiment 101.*—Four rats were fed in Washington, of which 1 developed a heavy infection, 2 developed slight infections, and 1 escaped infection entirely. The results of feeding experimental animals in Chicago were also positive. The sausage was 2 days in transit from Chicago to Washington.

*Experiment 104.*—An examination of several decapsuled larvæ in the laboratory at Washington showed that most of them were uncoiled, but that a few were coiled and active. Four rats fed portions of the sausage developed heavy infections. The results of feeding animals in Chicago were also positive. This sausage was 3 days in transit from Chicago to Washington.

*Experiment 105.*—Three rats were fed in the laboratory at Washington; 2 escaped infection and 1 developed a slight infection, showing but 2 encysted trichinæ in the diaphragm. Results positive in Chicago. The sausage was 2 days in transit from Chicago to Washington.

*Experiment 107.*—Results of feeding experiments in Washington negative; positive in Chicago. The sausage was 2 days in transit from Chicago to Washington.

*Experiment 108.*—Six rats were fed in Washington; 3 developed moderate infections and 3 escaped infection. Results in Chicago positive. The sausage was 2 days in transit from Chicago to Washington.

*Experiment 114.*—Three rats fed in Washington developed mild infections. Results in Chicago positive. The sausage was 4 days in transit from Chicago to Washington.

The data with reference to this sausage indicate that trichinæ may show considerable variation in vigor and resistance to unfavorable conditions, since larvæ from certain carcasses survived treatment apparently similar to that under which larvæ from other carcasses failed to survive.

### SAUSAGE SMOKED AT TEMPERATURES OF ABOUT 125° TO 130° F.

A considerable number of experiments were carried out at four establishments to determine the possibility of preparing sausage of kinds customarily eaten without cooking so as to obviate the necessity of a relatively long period of drying and yet render the product innocuous so far as concerns trichinæ. To compensate for the omission of drying, high-temperature smoking was substituted. This further necessitated a relatively brief smoking period, since prolonged high-temperature smoking would tend to impart to the sausage a cooked flavor and thus injure its commercial qualities.

As a result of certain laboratory experiments, some of which have been presented in a former paper (Ransom and Schwartz, 1919), it has been shown that trichinæ die at temperatures considerably below their thermal death point, provided they are held at these temperatures for sufficiently long periods. This fact was given consideration in arranging the experiments with this variety of sausage. The fact that salt was mixed with the meat was also taken into consideration, since a series of experiments, to be described later, demonstrated that as a result of a previous exposure to salt for a certain period encysted larvæ become more susceptible to heat than those which have not been exposed to the action of salt or which have been exposed for briefer periods.

The feeding tests with this sausage were carried out at the laboratories of meat-packing establishments and in Washington, as follows: Some of the sausage from each test was fed to experimental animals at the laboratory of the Zoological Division, Washington, D. C., where sausage of each lot was sent as well as some meat from other sausage of the same lot from which the salt had been removed by washing with water. This involved the use of two series of rats in testing the sausage and the washed meat sent to Washington and enabled us to determine whether the continued action of the salt in the sausage during the period required to ship it from Chicago to Washington might play a part in the destruction of the parasites. The sausage prepared at Establishments 2A and 3 was fed to experimental animals at the laboratories of the respective establishments and at the bureau laboratory in Chicago. The sausage prepared at Establishment 314 was fed at the laboratories of Establishments 2A and 3 and at the bureau's laboratory. Feeding tests with sausage prepared at Establishment 537 were conducted at the bureau laboratory at Chicago, at the laboratory of Establishment 2A, and in the laboratory of the Zoological Division in Washington.

In all, 57 experiments were carried out with sausage prepared from trimmings from 74 hogs. The sausages ranged in weight from three-fourths of a pound to 5 pounds. The shrinkage in the case of the smaller-sized sausages varied from about 20 to 30 per cent of the weight of the green sausages, whereas the larger-sized sausages lost only 10 to 15 per cent of their green weight as a result of the various treatments to which they were subjected.

In these experiments the sausage was smoked for 12 hours following a preliminary curing period in cooler and green room. During the smoking period the temperature varied considerably, but from the fifth to the ninth hour it was usually maintained in the neighborhood of 128° F. or higher and then allowed to go down gradually during the remainder of the smoking period, but not below 90° F. In other words, the 12-hour smoking period consisted of three stages, approximately as follows: Four hours were required to bring the temperature of the smokehouse to or near the maximum to be attained; during the next four hours the smokehouse was kept at about the maximum temperature, and finally the temperature was allowed to go down gradually to 90° F. or at least to approach this temperature.

This method of smoking following an adequate curing period proved to be efficacious in destroying the vitality of trichinæ, as the data presented below will show. The records are seen in Tables 9, 10, 11, and 12, grouped according to the establishments at which the experiments were conducted.

TABLE 9.—*Experiments with fresh summer sausage.*

(ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. Maximum. | Temperature. Minimum. | Time in dry room. | Temperature. Maximum. | Temperature. Minimum. | Time in smoke room. | Temperature. Maximum. | Temperature. Minimum. | Temperatures of smokehouse, °F.[1] | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | | |
| 118 | 7 and 8... | 7 | 40 | 33 | ...... | ..... | .... | 12 | 130 | 100 | 100, 108, 108, 110, 112, 118, 118, 120, 120, 121, 128, 130, 118. | ([2]). |
| 118a | 9 and 10.. | 3 | 36 | 34 | ⅝ | 65 | 63 | 12 | 126 | 100 | 100, 108, 118, 124, 126, 124, 118. | Negative. |
| 119 | 11........ | 3 | 38 | 35 | 1¾ | 60 | 51 | 12 | 128 | 82 | 82, 91, 99, 111, 118, 127, 128, 128, 126, 127, 115, 99, 95. | ([3]). |
| 120 | 12 and 13. | 3 | 36 | 33 | ½ | 64 | 63 | 12 | 126 | 90 | 90, 99, 110, 120, 126, 126, 126, 126, 126, 114, 114, 114, 115. | ([4]). |
| 121 | 14 and 15. | 1⅝ | 39 | 35 | 1 | 65 | 60 | 12 | 127 | 78 | 78, 88, 97, 103, 105, 124, 127, 123, 124, 127, 119, 114, 111. | Negative. |
| 122 | 16 and 17. | 3 | 41 | 37 | 2 | 71 | 67 | 24 | 130 | 80 | 80, 81, 83, 84, 84, 84, 84, 94, 108, 127, 130, 127, 127, 127, 116, 103, 106. | Do. |
| 123 | 18 and 19. | 3 | 44 | 35 | 2¾ | 70 | 62 | 15 | 130 | 72 | 72, 80, 90, 102, 109, 118, 125, 130, 128, 128, 126, 119, 111, 110. | Do. |
| 124 | 18 and 19. | 3 | 41 | 34 | [5] 2 | 71 | 63 | 15 | 129 | 80 | 80, 82, 89, 109, 112, 127, 126, 127, 128, 129, 122, 112, 110. | Do. |
| 125 | 20 and 21. | 3 | 43 | 40 | 2½ | 72 | 65 | 15 | 128 | 76 | 76, 92, 111, 126, 128, 127, 127, 128, 122, 119, 114, 111, 108. | Do. |
| 126 | 22 and 23. | 4 | 46 | 37 | 1 | 86 | 81 | 12 | 129 | 96 | 96, 108, 129, 129, 129, 120, 110.. | Do. |
| 127 | 24 and 25. | 5⅝ | 45 | 36 | ...... | ..... | .... | 12 | 131 | 94 | 94, 107, 112, 122, 128, 130, 129, 131, 130, 121, 114, 109. 95. | Do. |
| 128 | 26 and 27. | 4¼ | 40 | 33 | 1 | 68 | 63 | 12 | 130 | 90 | 90, 95, 98, 121, 128, 130, 130, 130, 130, 121, 115, 110, 104. | Do. |
| 129 | 28 and 29. | 4 | 39 | 35 | 1¾ | 66 | 62 | 12 | 132 | 97 | 101, 102, 109, 120, 129, 130, 131, 130, 132, 116, 105, 102, 97. | Do. |
| 130 | 30........ | 4 | 42 | 37 | 1⅝ | 65 | 59 | 12 | 130 | 94 | 94, 98, 104, 123, 129, 128, 130, 129, 129, 121, 114, 108, 99. | Do. |
| 131 | 31........ | 5 | 41 | 37 | 1 | 62 | 61 | 12 | 131 | 90 | 95, 102, 110, 117, 128, 130, 130, 131, 129, 118, 104, 97, 90. | Do. |
| 132 | 32 and 33. | 4⅝ | 46 | 38 | 1 | 64 | 62 | 12 | 130 | 90 | 90, 99, 113, 121, 129, 130, 129, 130, 130, 120, 110, 98, 94. | Do. |
| 133 | 34........ | 4 | 42 | 36 | 1⅔ | 60 | 59 | 12 | 129 | 90 | 90, 100, 109, 118, 129, 128, 129, 128, 128, 123, 115, 101, 90. | Do. |
| 134 | 35 and 36. | 4¼ | 40 | 35 | 1⅔ | 70 | 67 | 12 | 129 | 92 | 92, 106, 114, 120, 128, 129, 128, 129, 129, 119, 113, 108, 102. | Do. |
| 135 | 37........ | 4⅝ | 43 | 37 | 1 | 77 | 74 | 12 | 130 | 91 | 91, 102, 112, 117, 128, 129, 129, 130, 130, 121, 114, 109, 105. | Do. |
| 136 | 38........ | 5⅓ | 40 | 36 | 1 | ..... | .... | 12 | 132 | 95 | 95, 102, 110, 119, 128, 129, 129, 132, 130, 118, 110, 104, 100. | Do.[6] |

---

[1] The temperatures were taken at the beginning of each hour and are given in the order in which they were taken. In a few cases the temperatures were taken once in 2 hours.

[2] Negative at Chicago; no tests at Washington.

[3] Negative at Chicago; positive and negative at Washington; see pages 20–21.

[4] Positive at Chicago; positive and negative at Washington; see page 21.

[5] In addition to 2 days at 71° to 63° F., this sausage was held 15 hours in an unused smokehouse at an undetermined temperature.

[6] One rat out of 3 at establishment 2A showed one trichina well encysted, evidently from a previous infection.

### TABLE 10.—*Experiments with fresh summer sausage.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time in smoke room. | Temperature | | Temperatures of smokehouse, °F.[1] | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | | |
| 137 | 7 and 8 | $2\frac{3}{4}$ | 36.5 | 33.5 | 2 | 63 | 59.5 | 12 | 128 | 100 | 100, 110, 109, 119, 119, 128 | Negative. |
| 138 | 9 to 11 | 3 | 39.5 | 36 | $3\frac{2}{3}$ | 62 | 59 | 23 | 130 | 100 | 100, 103, 103, 110, 130, 125 | Do. |
| 139 | 12 | 2 | 38.5 | 34.5 | $1\frac{5}{6}$ | 60 | 56 | $6\frac{1}{2}$ | 137 | 81.5 | 81.5, 108, 134.5, 128, 122, 134, 117, 137. | Do. |
| 140 | 13 and 14. | 3 | 40 | 34 | $1\frac{1}{3}$ | 59 | 58 | 9 | 130 | 90 | 90, 88, 96, 128, 114, 125, 120, 126, 126, 130. | Do. |
| 141 | 15 | 3 | 43 | 42 | $2\frac{3}{4}$ | 61 | 60 | 9 | 137 | 84 | 84, 95, 118, 126, 119, 124, 128, 128, 137. | Do. |
| 142 | 16 and 17. | 3 | 46 | 42 | $1\frac{1}{3}$ | 62 | 56 | $9\frac{1}{2}$ | 127 | 94 | 100, 94, 110, 118, 126, 118, 127, 124, 122, 110, 96. | Do. |
| 143 | 18 | 3 | 48 | 42 | 3 | 71.5 | 63 | 12 | 136 | 95 | 95, 100, 98, 110, 114, 126, 124.5, 136, 131, 129, 109, 102, 99. | Do. |
| 144 | 19 and 20. | 5 | 53 | 47 | $\frac{5}{6}$ | 78 | 78 | 12 | 135 | 99 | 102, 107, 110, 128, 133, 130, 135, 135, 120, 101, 102, 99. | Do. |
| 145 | 21 and 22. | 4 | 43 | 40 | $1\frac{5}{6}$ | 69 | 65 | 12 | 137 | 71 | 71, 120, 112, 122, 128, 130, 137, 120, 118, 124, 125, 121, 118. | Do. |
| 146 | 24 and 25. | 4 | 46 | 43 | $1\frac{5}{6}$ | 65 | 58 | 12 | 140 | 90 | 90, 106, 110, 112, 116, 140, 132, 127, 128, 121, 117, 112, 110. | Do. |
| 147 | 26 and 27. | 4 | 44 | 38 | 2 | 63 | 54 | 12 | 130 | 90 | 90, 95, 100, 107, 122, 129, 130, 128, 129, 128, 114, 116, 112. | Do. |
| 148 | 28 and 29. | 4 | 44 | 37 | $1\frac{3}{4}$ | 59 | 58 | 12 | 142 | 80 | 80, 110, 109, 113, 120, 124, 128, 126, 142, 126, 111, 94, 91. | Do. |
| 149 | 30 and 31. | 4 | 46 | 43 | 2 | 63 | 55 | 12 | 132 | 94 | 94, 110, 107, 105, 98, 127, 132, 125, 124, 120, 122, 118, 119. | Do. |
| 150 | 32 and 33. | 5 | 48 | 44 | 1 | 60 | 60 | 12 | 138 | 90 | 90, 100, 118, 124, 123, 132, 138, 138, 136, 130, 133, 135, 132. | Do. |
| 151 | 34 and 35. | 5 | 44 | 43 | 1 | 48 | 46 | 12 | 133 | 90 | 90, 100, 98, 95, 102, 133, 132, 127, 125, 105, 116, 112, 110. | Do. |
| 152 | 36 and 37. | 4 | 42 | 40 | $2\frac{3}{4}$ | 80 | 54 | 12 | 130 | 90 | 90, 90, 94, 92, 117, 129, 130, 129, 128, 128, 115, 106, 106. | Do. |
| 153 | 38 and 39. | 4 | 49 | 43 | $1\frac{5}{6}$ | 65 | 61 | 12 | 130 | 91 | 98, 91, 97, 96, 110, 130, 129, 129, 130, 120, 108, 102, 100. | Do. |

[1] The temperatures were taken at the beginning of each hour and are given in the order in which they were taken.

### TABLE 11.—*Experiments with fresh summer sausage.*

(ESTABLISHMENT 537.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time in smoke room. | Temperature. | | Temperatures of smokehouse, °F.[1] | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | | |
| 154 | 3 and 4 | 3 | 40 | 36 | $1\frac{1}{2}$ | 72 | 70 | 12 | 128 | 85 | 85, 90, 100, 108, 112, 118, 120, 122, 128, 122, 118, 116, 110. | Negative. |
| 155 | 3 and 4 | $2\frac{1}{2}$ | 40 | 36 | $1\frac{1}{2}$ | 72 | 68 | 12 | 128 | 105 | 105, 111, 114, 116, 120, 122, 122, 122, 124, 114, 128, 124, 118. | Do. |
| 156 | 14 and 15[2] | 2 | 40 | 36 | $3\frac{2}{3}$ | 70 | 66 | 12 | 132 | 70 | 70, 78, 85, 92, 115, 120, 128, 126, 126, 128, 132, 115, 108. | Do. |
| 157 | 14 and 15[2] | 3 | 38 | 34 | $2\frac{1}{2}$ | 68 | 62 | 12 | 70 | 134 | 70, 80, 86, 91, 112, 120, 126, 130, 132, 134, 128, 126, 116. | Do. |
| 158 | 14 and 15[2] | 3 | 38 | 34 | $2\frac{1}{2}$ | 68 | 64 | 12 | 130 | 76 | 76, 78, 92, 105, 115, 120, 128, 130, 130, 128, 130, 128, 112. | Do. |

[1] The temperatures were taken at the beginning of each hour and are given in the order in which they were taken.

[2] These hogs belonged to the series of experimental hogs used at Establishment 2A.

TABLE 12.—*Experiments with fresh summer sausage.*

(ESTABLISHMENT 314.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in dry room. | Temperature. | | Time in smoke room. | Temperature. | | Temperatures of smokehouse, °F.[1] | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | | |
| 159 | 1 to 3 | 3 | 38 | 33 | 1⅔ | 70 | 68 | 12 | 126 | 108 | 114, 114, 125, 116, 122, 126, 115, 115, 110, 112, 112, 110, 108. | Negative. |
| 160 | 1 to 3 | 5 | 38 | 33 | 1½ | 72 | 68 | 12 | 127 | 88 | 88, 96, 110, 115, 120, 124, 126, 127, 125, 122, 118, 112. | Do. |
| 161 | 1 to 3 | 7 | 40 | 33 | 2½ | 70 | 68 | 12 | 126 | 92 | 92, 92, 98, 102, 108, 117, 117, 118, 115, 126, 122, 120, 118. | Do. |
| 162 | 4 | 2 | 38 | 34 | 2½ | 70 | 68 | 12 | 126 | 92 | 92, 92, 98, 102, 108, 117, 117, 118, 115, 126, 122, 120, 118. | Do. |
| 163 | 4 | 3 | 38 | 34 | 1⅔ | 70 | 64 | 12 | 127 | 105 | 90, 105, 111, 114, 119, 122, 120, 122, 122, 124, 127, 117, 110. | Do. |
| 164 | 4 | 2 | 38 | 34 | 1⅔ | 68 | 68 | 12 | 126 | 106 | 110, 112, 115, 118, 120, 126, 106, 118, 113, 110, 110, 108, 108. | Do. |
| 165 | 4 | 2 | 38 | 36 | 2½ | 70 | 66 | 12 | 127 | 95 | 90, 95, 108, 111, 118, 124, 127, 125, 120, 118, 116, 114, 110. | Do. |
| 166 | 5 | 3 | 38 | 34 | 2½ | 70 | 68 | 12 | 127 | 90 | 90, 90, 108, 108, 115, 115, 115, 127, 118, 122, 118, 110, 104. | Do.[2] |
| 167 | 5 | 3 | 40 | 36 | 2½ | 72 | 68 | 12 | 130 | 88 | 88, 93, 96, 98, 108, 114, 117, 130, 128, 122, 122, 120, 118. | Do.[2] |
| 168 | 11[3] | 3 | 38 | 36 | 1½ | 70 | 68 | 12 | 138 | 68 | 58, 62, 68, 78, 88, 100, 116, 130, 120, 124, 120, 120, 111. | Do. |
| 169 | 11[3] | 2 | 40 | 38 | 1½ | 68 | 66 | 12 | 132 | 75 | 64, 76, 86, 98, 111, 115, 122, 124, 124, 123, 130, 118.5, 112. | Do. |
| 170 | 11[3] | 2 | 40 | 36 | 2½ | 70 | 66 | 12 | 132 | 67 | 67, 73, 75, 79, 104, 117, 127, 126, 132, 126, 126, 115, 108. | Do. |
| 171 | 13 and 14[4] | 2 | 40 | 36 | 1½ | 70 | 66 | 12 | 132 | 70 | 70, 74, 78, 98, 126, 128, 128, 132, 130, 128, 121, 117, 112. | (4,5) |
| 172 | 13 and 14[4] | 2 | 38 | 35 | 2½ | 70 | 66 | 12 | 128 | 68 | 68, 80, 90, 110, 120, 126, 127, 126, 128, 126, 118, 110, 102. | Negative. |
| 173 | 13 and 14[4] | 3 | 40 | 35 | 3 | 70 | 66 | 12 | 132 | 76 | 76, 77, 77, 97, 126, 126, 130, 132, 128, 128, 124, 112, 107. | (6) |

[1] The temperatures were taken at the beginning of each hour and are given in the order in which they were taken.
[2] Negative at Chicago; no tests at Washington.
[3] Trimmings for this test obtained from Hog 11 of the series used at Establishment 2.
[4] Trimmings for this test were obtained from Hogs 13 and 14 of the series used at Establishment 3.
[5] Positive and negative at both Chicago and Washington, see page 21.
[6] Negative at Chicago, negative and positive at Washington, see page 21.

An examination of the data presented in Tables 9, 10, 11, and 12 shows that in the majority of the experiments the sausage was smoked for 12 hours following a preliminary curing period which varied considerably in duration, but did not as a rule exceed 6 days. Some of the sausages of each lot prepared at Establishments 2A and 3 were freed from their salt content as soon as they were taken out of the smokehouse and were fed to experimental animals at the establishment and bureau laboratories in Chicago. Some of the test animals in 4 of the 57 experiments became infected. In two of these 4 experiments the positive results from feeding animals are questionable, namely, Experiment 119 and Experiment 173.

In Experiment 119 some of the sausage was ground up and washed to remove the salt shortly after it reached the Washington laboratory.

The meat was fed to 4 rats, all of which escaped infection. Portions of meat from the same lot of sausage which was freed from its salt content in Chicago before being shipped to Washington were fed to 4 rats, one of which became slightly infected, only 12 encysted trichinæ being discovered in the entire diaphragm. Portions of sausage from this lot were fed to 3 rats at the laboratory of Establishment 2A and to several mice at the bureau's laboratory at Chicago, but none of these animals developed an infection.

In Experiment 173 4 rats fed in Washington on sausage meat freed from its salt content in Chicago did not become infected. Of 4 rats which were fed portions of sausage forwarded to the Washington laboratory 3 escaped infection and 1 developed a moderate infection. Portions of sausage of the same lot were fed to experimental animals at Chicago without producing infection, as follows: Three rats at the laboratory of Establishment 2A, 3 mice at the laboratory of Establishment 3, and 3 mice at the bureau laboratory. This makes a total of 17 animals to which this meat was fed, of which only 1 developed an infection. In view of the negative results at three different laboratories at Chicago, the one positive result at Washington appears rather questionable, particularly because, according to the records, the intact sausage produced the infection, whereas the washed sausage meat yielded negative results.

The details of feeding tests in the 2 other experiments which yielded positive results are as follows:

In Experiment 120 portions of the intact sausage were fed to 3 rats, none of which became infected. The sausage meat deprived of its salt content in Chicago was fed to 4 rats at the Washington laboratory. Of these 1 escaped infection, 1 developed a moderate infection, and 2 developed very slight infections, showing 1 and 4 encysted larvæ, respectively, in their diaphragms. Three rats to which sausage from this test was fed at the establishment laboratory in Chicago escaped infection. Several mice fed at the bureau laboratory in Chicago were also negative.

In Experiment 171, 4 rats fed portions of several sausages shipped to Washington escaped infection. Sausage meat freed from its salt content at Chicago and shipped to Washington was fed to 4 rats, 1 of which escaped from the cage and was not afterwards found. Of the remaining rats 2 became heavily infected and 1 developed a mild infection. Three mice were fed at the laboratory of Establishment 3, of which 1 became infected and 2 escaped infection. Two additional lots fed in Chicago escaped infection.

Summarizing the results of the feeding experiments with this variety of sausage, 4 tests yielded positive results, which in case of Experiment 173 is of doubtful validity and for which extraneous infection may have been responsible. The results of Experiment 119 also appear doubtful in view of the negative results obtained at Chicago. Of the remaining tests, one, Experiment 120, produced a very mild infection in 1 out of 14 test animals. The sausage in these tests was subjected to very short curing periods—less than 6 days—which may perhaps account for the positive results. It is interesting to observe in this connection that intact sausage in these latter tests that was forwarded to Washington was innocuous as shown by the results of the feeding experiments, indicating that the continued salt action for an additional period of a few days (4 days in each case) was the probable factor that brought about a complete destruction of the parasites.

Inasmuch as preliminary curing of sufficient duration appears to be a decided factor in destroying trichinæ, as well as the temperature and duration of smoking, the bureau specifications for the preparation of fresh summer sausage containing the muscle of pork require at least 6 days of curing to be followed by at least 12 hours of smoking, of which the first 4 hours may be utilized for raising the temperature of the smokehouse to at least 128° F. The smokehouse is required to be maintained at this or a higher temperature for the succeeding 4 hours, and may then be lowered gradually to not less than 90° F., a period of not less than 4 hours being consumed in lowering the temperature.

### EXPERIMENTS WITH ITALIAN STYLE HAMS.

The experiments with Italian style hams carried out at Establishments 2A and 3 were 58 in number, each of which involved the preparation of from 2 to 6 hams. These ranged in weight from about 10 pounds to 36 pounds when placed in cure. The hams utilized in the experiments were obtained from 105 hog carcasses. In practice the hams selected for preparation as Italian style hams are usually obtained from lean stock and generally range in weight from 12 to 17 pounds. The following method was employed in the preparation of the experimental hams:

The hams were cured by a dry-curing process. The curing mixture consisted of salt (on the basis of 4 pounds per hundredweight of meat), sugar, and potassium nitrate. In addition to the curing mixture, a pickle solution was generally used, this being injected into the hams with a pickle pump. The dry salt was applied in a thorough manner to the lean meat of each ham. The pickle solution, which generally contained about 25 per cent of salt, was injected in small quantities in the shank and flank side of the body of the ham. Between the seventeenth and the twentieth days after the beginning of the cure the hams were overhauled and additional salt was applied. At the end of 40 days the hams prepared at Establishment 3 were taken out of cure and soaked for a few hours in warm water at a temperature not exceeding 70° F., but were not subjected to any other treatment designed to remove the salt from the meat, except superficial washing. The hams prepared at Establishment 2A were cured for varying periods, depending upon their weight as indicated later. Upon removal from cure they were subjected to soaking and superficial washing as described above. The subsequent treatments consisted either (1) in smoking or so-called pale-drying (drying in a warm room) at a temperature not lower than 95° F., or (2) smoking for various periods as shown in the table at a temperature not lower than 80° F., followed by a period of drying of not less than 20 days at a temperature not lower than 45° F.

The records of experiments with hams summarized in Table 13 were preliminary to experiments summarized in Tables 14 and 15, the hams having been prepared from an earlier series of experimental hogs.

TABLE 13.—*Experiments with Italian style hams.*[1]

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat.[2] | Number of hams. | Weights of hams. | Preliminary curing. Time in cooler. | Preliminary curing. Temperature. Maximum. | Preliminary curing. Temperature. Minimum. | Drying. Time in dry room. | Drying. Temperature. Maximum. | Drying. Temperature. Minimum. | Results of tests on animals at Washington. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Hog.* | | *Lbs.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | | |
| 196 | 1............ | 1 | 32½ | 55 | 36½ | 32 | 10 | 105 | 92 | Negative.. | 3 days en route plus 8 days in cold room. |
| 197 | 2 and 3...... | 2 | 24¾-27 | 55 | 36½ | 32 | 10 | 102 | 90 | ...do....... | 4 days en route plus 4 days in ice box. |
| 198 | 4 and 5...... | 2 | 28 -28½ | 54 | 36½ | 32 | 10 | 102 | 90 | ...do....... | Do. |
| 199 | 6 and 7...... | 2 | 24½-26½ | 55 | 37 | 33 | 10 | 102 | 92 | ...do....... | 3 days en route plus 3 days in ice box. |
| 200 | 8 to 10....... | 3 | 30¾-40 | 51 | 38 | 35 | 10 | 102 | 91 | ...do....... | 4 days en route. |
| 201 | 1 to 4........ | 4 | 27½-30¾ | 39 | 38 | 35½ | 10 | 101 | 89 | ...do...... | 2 days en route. |
| 202 | 5 to 7 and 11. | 4 | 15 -27 | 29 | 38 | 35 | 10 | 103 | 91 | ...do...... | Do. |
| 203 | 13............ | 1 | 29¼ | 49 | 38 | 35 | 10 | 102 | 91 | ...do...... | 6 days en route. |
| 204 | 14 to 17...... | 4 | 25¼-28¾ | 59 | 38 | 34½ | 10 | 104 | 98 | ...do...... | 3 days en route. |
| 205 | 197 and 200.. | 2 | ........ | 45 | ..... | ..... | 10 | 115 | 100 | ...do....... | 1 week en route. |

---

[1] These experiments were preliminary to experiments which are summarized in Table 14 and were performed before the 40-day curing period was adopted.

[2] The hogs referred to in this table do not belong to the same series as that used for preparing the various experimental products described in this paper as having been prepared at Establishment 3.

An examination of Table 13 shows that in Experiments 196 to 205, inclusive, there was a lack of uniformity as regards the duration of the curing period, for the reason that these experiments were preliminary to experiments performed at a later date and summarized in Tables 14 and 15. Following in Table 14 is a record of the experiments conducted at Establishment 3. These hams were smoked or pale-dried following the curing process. In the 22 experiments, summarized in Table 14, a uniform 40-day curing period was maintained, except that in two instances the hams were cured 41 days, and in one instance 42 days. Inasmuch as these 22 experiments were made with hams of various sizes including very large hams, it appears quite evident that curing periods of more than 40 days are entirely superfluous so far as concerns the destruction of trichinæ, if the hams are afterwards dried for 10 days at a temperature of about 100° F. The temperatures attained during the process of smoking or pale-drying are fairly uniform for the entire series of experiments.

In view of the results obtained in this series of experiments, the method of preparation followed has been approved by the bureau as a method by which hams of this kind may be prepared in establishments operating under Federal inspection. In brief, the regulations specify a dry-salt cure on the basis of 4 pounds of salt per 100 pounds of meat; a period of curing of not less than 40 days at a temperature not lower than 36° F. to be followed by smoking or pale-drying for 10 days at a temperature not lower than 95° F.

TABLE 14.—*Experiments with Italian style hams.*[1]

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Number of hams. | Weights of hams. | Preliminary curing.[2] |  |  | Drying. |  |  | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | Time in cooler. | Temperature. |  | Time in dry room. | Temperature. |  |  |
|  |  |  |  |  | Maximum. | Minimum. |  | Maximum. | Minimum. |  |
|  | *Hog.* |  | *Pounds.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* |  |
| 174 | 1 and 2.... | 4 | 20½–25 | 40 | 38 | 35 | 10 | 110 | 93 | Negative. |
| 175 | 3 and 4.... | 4 | 31 –33½ | 40 | 38 | 36 | 10 | 107 | 96 | Do. |
| 176 | 5 and 6.... | 4 | 26 –27½ | 40 | 39 | 35 | 10 | 104 | 95 | Do. |
| 177 | 7 and 8.... | 4 | 18¾–27¼ | 40 | 39 | 34 | 10 | 106 | 96 | Do. |
| 178 | 9 and 11... | 6 | 22½–28 | 40 | 36 | 34 | 10 | 106 | 96 | Do. |
| 179 | 12.......... | 2 | 25 –25½ | 40 | 38 | 34 | 10 | 108 | 95 | Do. |
| 180 | 13 and 14.. | 4 | 28½–31 | 40 | 37 | 34 | 10 | 111 | 96 | Do. |
| 181 | 15.......... | 2 | 23 –24 | 40 | 38 | 34 | 10 | 110 | 95 | Do. |
| 182 | 16 and 17.. | 4 | 23 –26½ | 40 | 38 | 34 | 10 | 113 | 96 | Do. |
| 183 | 18.......... | 2 | 32½ | 40 | 38 | 34 | 10 | 114 | 102 | Do. |
| [3] 184 | 19 and 20.. | 4 | 10¾–14½ | 40 | 43 | 34 | 10 | 116 | 93 | Do. |
| [3] 185 | 21 and 22.. | 4 | 13 –15 | 40 | 41 | 33 | 10 | 105 | 95 | Do. |
| [3] 186 | 23.......... | 2 | 11 –11½ | 40 | 40 | 35½ | 11 | 105 | 95 | Do. |
| [3] 187 | 24 and 25.. | 4 | 12 –13¼ | 40 | 40 | 36 | 10 | 110 | 98 | Do. |
| [3] 188 | 26 and 27.. | 4 | 14½–15 | 41 | 39 | 36 | 10 | 111 | 96 | Do. |
| [3] 189 | 28 and 29.. | 4 | 11½–18 | 40 | 40 | 33 | 11 | 112 | 95 | Do. |
| [3] 190 | 30 and 31.. | 4 | 11½–14½ | 40 | 42 | 31 | 10 | 108 | 82 | Do. |
| [3] 191 | 32 and 33.. | 4 | 8 –13½ | 40 | 40 | 38 | 10 | 113 | 93 | Do. |
| [3] 192 | 34 and 35.. | 4 | 12½–14½ | 41 | 41 | 37 | 10 | 110 | 90 | Do. |
| [3] 193 | 36 and 37.. | 4 | 10 –18 | 40 | 41 | 38 | 10 | 112 | 96 | Do. |
| [3] 194 | 38 and 39.. | 4 | 14 –15½ | 40 | 40 | 35 | 9 | 112 | 95 | Do. |
| [3] 195 | 40 to 42.... | 6 | 17½–20 | 42 | 41 | 34 | 11 | 108 | 96 | Do. |

[1] All the hams in this series of experiments were soaked for 15 hours before drying.

[2] The hams were overhauled from 14 to 16 days after the beginning of the curing process, additional salt being applied.

[3] The hams in Experiments 184 to 195, both inclusive, were not pumped with pickle solution.

The experiments summarized in Table 15 were conducted at Establishment 2A. With the exception of Experiments 206 to 210, the products were cured on the basis of 3 days for each pound of weight of the individual hams, and were then smoked for 36 hours at a temperature of about 80° F., and finally dried for 20 days at a lower temperature.

TABLE 15.—*Experiments with Italian style hams.*

(ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Number of hams. | Weight of hams. | Preliminary curing.[1] | | | | | | | | | Pale drying (*a*) or smoking (*b*). | | | Drying. | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Salting. | | | Soaking. | | | Draining. | | | | | | | | | |
| | | | | Time in cooler. | Temperature. Maximum. | Temperature. Minimum. | Time. | Temperature. Maximum. | Temperature. Minimum. | Time in dry room. | Temperature. Maximum. | Temperature. Minimum. | Time. | Temperature. Maximum. | Temperature. Minimum. | Time. | Temperature. Maximum. | Temperature. Minimum. | |
| | *Hog.* | | *Pounds.* | *Dys.* | °*F.* | °*F.* | *Hrs.* | °*F* | °*F* | *Dys.* | °*F* | °*F* | *Hrs.* | °*F* | °*F.* | *Dys.* | °*F* | °*F* | |
| 206 | 1 to 3.... | 6 | $20\frac{1}{2}-30\frac{1}{2}$ | 47 | 39 | 33.5 | ...... | ... | ... | ...... | ... | ... | *b* 18 | 96 | 90 | 20 | 63 | 52 | Negative. |
| 207 | 4 to 6.... | 6 | $9\frac{1}{2}-12\frac{1}{2}$ | 42 | 37.5 | 33.5 | ...... | ... | ... | ...... | ... | ... | *b* 19 | 101 | 93 | 20 | 64 | 52 | Do. |
| 208 | 7 and 8.. | 4 | $23\frac{1}{2}-28\frac{1}{2}$ | 42 | 41 | 35 | ...... | ... | ... | ...... | ... | ... | *b* 18 | 99 | 97 | 20 | 66 | 51 | (2) |
| 209 | 9 and 10. | 4 | $30\frac{1}{2}-36\frac{1}{4}$ | 42 | 41 | 39 | ...... | ... | ... | ...... | ... | ... | *b* 18 | 99 | 97 | 19 | 57 | 52 | Positive. |
| 210 | 11....... | 2 | 23 | 47 | 41 | 38 | ...... | ... | ... | ...... | ... | ... | *b* 18 | 101 | 98 | 20 | 62 | 54 | (2) |
| 211 | 12 and 13 | 4 | $25\frac{1}{2}-27\frac{1}{2}$ | 80 | 40 | 38 | ...... | ... | ... | ...... | ... | ... | *a* 36 | 82 | 79 | 20 | 74 | 53 | Negative. |
| 212 | 14 and 15 | 4 | $24\frac{3}{4}-29\frac{1}{2}$ | 80 | 41 | 38 | 4 | 58 | 57 | $\frac{3}{4}$ | 42 | 40 | *b* 36 | 95 | 90 | 18 | 71 | 60 | Do. |
| 213 | 16 and 17 | 4 | $11\frac{1}{2}-12\frac{1}{2}$ | 38 | 40 | 38 | 4 | 51 | 50 | 2 | 40 | 35 | *a* 36 | 82 | 79 | 20 | 74 | 53 | Do. |
| 214 | 18 and 19 | 4 | $13\frac{1}{2}-16$ | 45 | 40.5 | 36 | 3 | 57 | 56 | 3 | 42 | 36 | *a* 36 | 91 | 79 | 21 | 75 | 61 | Do. |
| 215 | 20 and 21 | 4 | $22\frac{1}{4}-26$ | 75 | 40 | 38 | 4 | 65 | 57 | ...... | ... | ... | *a* 44 | 88 | 72 | 20 | 86 | 60 | Do. |
| 216 | 22 and 23 | 4 | $15\frac{1}{4}-16\frac{1}{4}$ | 48 | 43 | 41 | 3 | 67 | 64 | 1 | 46 | 42 | *b* 36 | 92 | 87 | 20 | 77 | 51 | Do. |
| 217 | 24 and 25 | 4 | $14\frac{1}{4}-18\frac{1}{4}$ | 50 | 40.5 | 38 | 3 | 55 | 53 | $2\frac{1}{4}$ | 39 | 36 | *b* 36 | 92 | 83 | 20 | 66 | 53 | Do. |
| 218 | 26 and 27 | 4 | $13-17\frac{3}{4}$ | 47 | 40 | 37.5 | 3 | 45 | 42 | 1 | 40 | 36 | *a* 34 | 95 | 81 | 21 | 60 | 47 | Do. |
| 219 | 28 and 29 | 4 | $16\frac{3}{4}-17\frac{1}{4}$ | 52 | 39 | 36 | 3 | 36 | 36 | $1\frac{5}{6}$ | 38 | 36 | *a* 32 | 87 | 84 | 20 | 60 | 46 | Do. |
| 220 | 30....... | 2 | $17-18$ | 53 | 39 | 36 | 3 | 36 | 36 | $\frac{5}{6}$ | 38 | 37 | *a* 32 | 91 | 84 | 20 | 62 | 51 | Do. |
| 221 | 31....... | 2 | $16\frac{1}{2}-16\frac{3}{4}$ | 49 | 39 | 37 | 3 | 42 | 41 | 2 | 39 | 36 | *b* 32 | 94 | 80 | 19 | 70 | 50 | Do. |
| 222 | 32 and 33 | 4 | $17-17\frac{1}{2}$ | 53 | 39 | 37 | 3 | 52 | 45 | $\frac{3}{4}$ | 40 | 39 | *a* 32 | 90 | 82 | 19 | 70 | 53 | Do. |
| 223 | 34....... | 2 | $10\frac{1}{2}$ | 33 | 39 | 37 | 3 | 52 | 50 | $1\frac{5}{6}$ | 40 | 38 | *a* 32 | 92 | 85 | 20 | 70 | 53 | Do. |
| 224 | 35 and 36 | 4 | $13-14\frac{1}{2}$ | 40 | 39 | 38 | 3 | 66 | 65 | 1 | 47 | 44 | *a* 30 | 86 | 73 | 19 | 86 | 63 | Do. |
| 225 | 37....... | 2 | $13\frac{1}{4}-13\frac{1}{2}$ | 42 | 39 | 37 | 4 | 65 | 65 | $\frac{5}{6}$ | 44 | 40 | *a* 30 | 92 | 84 | 19 | 91 | 53 | Do. |
| 226 | 38....... | 2 | $18\frac{3}{4}-20$ | 60 | 39 | 36 | 3 | 46 | 45 | $\frac{3}{4}$ | 61 | 60 | *a* 36 | 87 | 81 | 20 | 59 | 51 | Do. |
| 227 | 39....... | 2 | $18\frac{1}{2}-19$ | 57 | 39 | 35 | 3 | 38 | 35 | $\frac{5}{6}$ | 42 | 39 | *a* $49\frac{1}{2}$ | 90 | 78 | 20 | 60 | 53 | Do. |
| 228 | 40....... | 2 | $15\frac{1}{2}-15\frac{3}{4}$ | 46 | 39 | 35 | 3 | 65 | 64 | $\frac{5}{6}$ | ... | ... | *a* 48 | 94 | 84 | 23 | 58 | 52 | Do. |
| 229 | 41 and 42 | 4 | $9\frac{1}{2}-14\frac{3}{4}$ | 47 | 40 | 34 | 2 | 42 | 40 | 11 | 53 | 53 | *a* 49 | 90 | 81 | 20 | 63 | 52 | Do. |
| 230 | H....... | 2 | $29-30$ | 65 | 50 | 32 | ...... | ... | ... | ...... | ... | ... | *b* 19 | 118 | 90 | 25 | 68 | 58 | Do.[4] |
| [5] 231 | B, D, E. | 3 | $6\frac{1}{2}-8$ | 56 | 50 | 32 | ...... | ... | ... | ...... | ... | ... | *b* 19 | 115 | 68 | 11 | 64 | 59 | Do.[4] |

---

[1] These hams were overhauled from 15 to 22 days after the beginning of the curing process, additional salt being applied. In a few instances the hams were overhauled a second time.

[2] Negative and positive at Chicago; negative at Washington.

[3] Larvæ examined 3 days after hams were taken out of dry room. This experiment was preliminary to the other experiments in this series.

[4] Negative at Washington. No test at Chicago.

[5] Larvæ examined 12 days after hams were taken out of dry room. This experiment was preliminary to the other experiments in this series.

The hams in Experiments 206 to 210 were smoked only 18 hours and cured for periods of less than 3 days per pound. Portions of meat from Experiment 209 infected 3 rats at the laboratory of Establishment 2A. In the Washington laboratory portions of the hams in this experiment were fed to 4 rats, 2 of which were eaten by the other rats in the same cage and no muscles were left for examination. The two remaining rats developed heavy infections. As shown in the table, these hams were rather heavy, a few exceeding 30 pounds in weight. Portions of ham from Experiments 208 and 210 infected the rats to which they were fed at the laboratory of Establishment 2A, but failed to infect rats in the laboratory of the Zoological Division. The details of these experiments are as follows:

Experiment 208 (Establishment 2A), 2 hams, identified as 7 AH and 7 BH, failed to infect rats (3 for each ham) fed at Establishment

2A. Two hams, identified as 8 AH and 8 BH (28 to 28½ pounds) infected rats (3 for each ham) fed at Establishment 2A. Portions of these various hams fed to rats at Washington failed to infect them.

Experiment 209 (Establishment 2A), positive; 12 rats fed hams, identified as 9 AH, 9 BH, 10 AH, and 10 BH, at Establishment 2A; 3 rats for each ham. Rats in Washington also positive.

Experiment 210 (Establishment 2A), 3 rats, fed ham identified as 11 AH, positive; 3 rats, fed ham identified as 11 BH, negative, at Establishment 2A. Rats in Washington negative. Decapsuled larvæ obtained at the Washington laboratory from these hams by artificial digestion were uncoiled, a condition which is usually a fair indication of loss of vitality. Apparently the additional period involved in the shipment of the hams to Washington, during which time the salt in the meat continued to act, was sufficient to bring about the destruction of the vitality of the parasites.

The remaining 21 experiments in which the hams were cured on the basis of 3 days for each pound of weight of the individual hams, then smoked for 36 hours, and finally dried for a period of 20 days yielded uniformly negative results. A method of preparing hams similar to that used in the experiments has accordingly been approved by the bureau. The specifications for this method may be expressed in brief as follows:

Three days' cure for each pound of weight of the individual hams (4 pounds of salt per hundredweight), to be followed by at least 48 hours of smoking at a temperature not lower than 80° F., and finally by drying for at least 20 days at a temperature not lower than 45° F.

### EXPERIMENTS WITH CAPICOLA.

Capicola is a name applied to certain products which consist of boneless pork butts from which the superficial fat has been removed, stuffed in beef-bung casings. The butts are cured by a dry-curing process involving the use of the usual curing mixtures. In the experiments described below, 44 in number, the salt in the curing mixture amounted to 4½ pounds per hundredweight of meat at Establishment 2A and 5 pounds per hundredweight of meat at Establishment 3. The experimental butts obtained from trichinous hog carcasses were placed with other butts in a tierce to which sweet pickle of 80° salometer strength was added in the experiments at Establishment 3, and 35° to 40° strength at Establishment 2A. These variations were made in conformity with the methods regularly employed at these establishments. During the curing process the butts were generally overhauled by rolling the tierce at certain intervals.

Following the curing process the products were smoked for 30 hours or longer at temperatures usually not lower than 80° F. and finally dried for a number of days.

In the experiments butts from 90 carcasses were used. With a few exceptions four pieces of capicola, which generally ranged in weight from about 2 to 3½ pounds, were prepared for each experiment. The shrinkage averaged about 20 per cent of the weight of the freshly stuffed products.

The results of these tests are summarized in Tables 16 and 17.

TABLE 16.—*Experiments with capicola.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Results of tests on animals at Chicago and Washington. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. Maximum. | Temperature. Minimum. | Time in green room. | Temperature. Maximum. | Temperature. Minimum. | Time in smoke room. | Temperature. Maximum. | Temperature. Minimum. | Time in dry room. | Temperature. Maximum. | Temperature. Minimum. | | |
| | *Hog.* | *Days* | ° *F.* | ° *F.* | *Days* | ° *F.* | ° *F.* | *Hrs.* | ° *F.* | ° *F.* | *Days* | ° *F.* | ° *F.* | | |
| 232 | 5 and 6.. | 27 | 41 | 35½ | 1¼ | 57 | 56 | 39 | 85 | 70 | 21 | 59 | 46 | Negative.. | |
| 233 | 7 and 8.. | 25 | 39 | 34½ | ⅝ | 59 | 58 | 39 | 108 | 68 | 21 | 60 | 43 | ...do....... | |
| 234 | 9 to 11... | 25 | 37 | 34½ | 2⅝ | 61 | 55 | 44 | 87 | 73 | 21 | 60 | 43 | ...do....... | |
| 235 | 12....... | 26 | 39 | 34 | 2 | 60 | 50 | 23 | 85 | 76 | 22 | 68 | 45 | ...do....... | |
| 236 | 13 and 14 | 25 | 38 | 34 | 3 | 59 | 57 | 62 | 76 | 72 | 20 | 68 | 45 | ...do....... | |
| 237 | 15....... | 27 | 40 | 34 | 1⅙ | 64 | 52 | 28 | 90 | 82 | 21 | 68 | 44 | ...do....... | |
| 238 | 16 and 17 | 25 | 41 | 36 | 3 | 63 | 44 | 28 | 79 | 66 | 22 | 72 | 49 | ...do....... | |
| 239 | 18....... | 25 | 44 | 35 | ⅝ | 74 | 64 | 22½ | 104 | 87 | 21 | 76 | 54 | ...do....... | |
| 240 | 19 and 20 | 26 | 43 | 36 | ⅝ | 78 | 72 | 37 | 100 | 81 | 20 | 84 | 53 | ...do....... | |
| 241 | 21 and 22 | 24 | 39 | 34 | 3 | 63 | 55 | 27 | 85 | 79 | 20 | 64 | 49 | ...do....... | |
| 242 | 24 and 25 | 25 | 39 | 34 | 1⅙ | 68 | 54 | 33 | 82 | 74 | 23 | 60 | 47 | ...do....... | |
| 243 | 26 and 27 | 25 | 38 | 35 | 1½ | 70 | 57 | 32 | 98 | 66 | 22 | 51 | 39 | ...do....... | |
| 244 | 28 and 29 | 25 | 39 | 36 | 2½ | 70 | 64 | 20 | 90 | 74 | 19 | 51 | 46 | ...do....... | |
| 245 | 30 and 31 | 26 | 40 | 35 | 2 | 68 | 59 | 36 | 90 | 79 | 20 | 52 | 45 | ...do....... | |
| 246 | 32 and 33 | 25 | 40 | 35 | 2 | 62 | 49 | 36 | 89 | 79 | 22 | 69 | 47 | ...do....... | |
| 247 | 34 and 35 | 27 | 40 | 33 | 3 | 53 | 49 | 37 | 83 | 75 | 21 | 74 | 50 | ...do....... | |
| 248 | 36 and 37 | 26 | 40 | 34 | 1¾ | 76 | 61 | 37 | 87 | 82 | 21 | 93 | 65 | ...do....... | |
| [1]250 | 9 and 10. | 30 | 43 | 37 | ..... | .... | .... | 48 | 77 | 60 | 30 | 74 | 46 | ...do.[2]..... | 3 days en route. |
| [1]251 | 3,4, and 8 | 27 | 43 | 38 | ..... | .... | .... | 24 | 78 | 68 | 29 | 74 | 46 | ...do.[2]..... | 4 days en route. |
| [1]252 | 1, 2, and 5 | 20 | 43 | 37 | ..... | .... | .... | 24 | 72 | 65 | 41 | 74 | 46 | ...do.[2]..... | Do. |
| [1]253 | 6, 7, 11.. | 16 | 40½ | 37 | ..... | .... | .... | 24 | 83½ | 82 | 41 | 65 | 46 | ...do.[2]..... | 3 days en route. |
| [1]254 | 13....... | 27 | 43 | 37 | ..... | .... | .... | 48 | 77 | 60 | 30 | 74 | 46 | ...do.[2]..... | Do. |
| [1]255 | 14 to 17.. | 35 | 44 | 37 | ..... | .... | .... | 60 | 92 | 70½ | 27 | 74 | 49 | ...do.[2]..... | 5 days en route. |

---

[1] Experiments 250 to 255 were preliminary to the other experiments summarized in this table, the pork in these cases having been obtained from an earlier series of hogs.

[2] No tests at Chicago.

TABLE 17.—*Experiments with capicola.*

(ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature. | | | Temperature. | | | Temperature. | | | Temperature. | | |
| | | Time in cooler. | Maximum. | Minimum. | Time in dry room. | Maximum. | Minimum. | Time in smoke room. | Maximum. | Minimum. | Time in dry room. | Maximum. | Minimum. | |
| | *Hog.* | *Days.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | *Hours.* | *°F.* | *°F.* | *Days.* | *°F.* | *°F.* | |
| 256 | 4 to 6 | 26 | 40 | 34 | $\frac{5}{6}$ | 65 | 56 | 38 | 116 | 74 | 10 | 65 | 52 | Negative. |
| 257 | 7 and 8 | 20 | 36 | 33 | 3 | 64 | 60 | 45 | 106 | 65 | 7 | 61 | 52 | (1) |
| 258 | 9 and 10 | 27 | 37 | 33 | ...... | ..... | ..... | 35 | 100 | 86 | 3 | 60 | 55 | Positive. |
| 259 | 11 | 25 | 41 | 35 | 1 | 64 | 61 | 35 | 98 | 89 | $4\frac{1}{6}$ | 58 | 52 | Do. |
| 260[2] | 12 and 13 | 24 | 42 | 39 | 2 | 64 | 63 | 36 | 100 | 97 | 9 | 64 | 55 | (1) |
| 261 | 14 and 15 | 28 | 43 | 35 | 1 | 72 | 64 | 36 | 102 | 95 | 8 | 62 | 54 | Negative. |
| 262 | 16 and 17 | 25 | 41 | 35 | 1 | 68 | 63 | 40 | 95 | 84 | 14 | 65 | 53 | Do. |
| 263 | 18 and 19 | 25 | 41 | 34 | 1 | 78 | 67 | 34 | 100 | 82 | 16 | 74 | 61 | Do. |
| 264 | 20 and 21 | 25 | 43 | 36 | 1 | 72 | 67 | 36 | 101 | 95 | 14 | 75 | 61 | Do. |
| 265 | 22 and 23 | 29 | 52 | 38 | 1 | 81 | 77 | 32 | 107 | 88 | 10 | 86 | 60 | Do. |
| 266 | 24 and 25 | 29 | 42 | 34 | 2 | 73 | 63 | 30 | 98 | 80 | 10 | 66 | 50 | Do. |
| 267 | 26 and 27 | 29 | 41 | 34 | 2 | 64 | 55 | 30 | 102 | 83 | 10 | 60 | 53 | Do. |
| 268 | 28 and 29 | 32 | 39 | 34 | 1 | 66 | 62 | 30 | 93 | 88 | 10 | 63 | 50 | Do. |
| 269 | 30 | 31 | 39 | 32 | 1 | 64 | 58 | 30 | 96 | 85 | 9 | 58 | 52 | Negative.[3] |
| 270 | 31 | 31 | 42 | 33 | 2 | 66 | 62 | 30 | 92 | 84 | 9 | 62 | 54 | Do. |
| 271 | 32 and 33 | 29 | 42 | 32 | $1\frac{3}{4}$ | 67 | 59 | 32 | 98 | 85 | 10 | 70 | 56 | Do. |
| 272 | 34 | 31 | 42 | 32 | $2\frac{2}{3}$ | 72 | 63 | 32 | 100 | 87 | 10 | 68 | 60 | Do. |
| 249[4] | 35 and 36 | 31 | 45 | 35 | ...... | ..... | ..... | 32 | 98 | 84 | 10 | 82 | 65 | Do. |
| 273[4] | 35 and 36 | 31 | 45 | 35 | 2 | 70 | 67 | 32 | 98 | 84 | 10 | 82 | 65 | Negative.[3] |
| 274[4] | A to E and H. | 35 | 45 | 32 | ...... | ..... | ..... | $42\frac{1}{2}$ | 109 | 70 | 15 | 65 | 54 | No test. |
| 275[4] | E | 22 | 45 | 32 | ...... | ..... | ..... | ...... | ..... | ..... | ...... | ..... | ..... | Positive.[5] |

---

[1] Positive at Chicago, negative at Washington.

[2] Experiment 260; 3 rats (Establishment 2A) fed on smaller butts infected; 3 rats (Establishment 2A) fed on larger butts not infected. Rats fed in Washington not infected.

[3] Negative at Washington; no test at Chicago.

[4] Experiments 249, 273–275, were preliminary to the other experiments summarized in this table, the pork in these cases having been obtained from an earlier series of hogs. Before smoking, the butts were placed in the green room for 2 days at a temperature ranging from 67° to 70° F.

[5] Positive at Washington; no test at Chicago.

The data presented in Table 16, which cover the experiments conducted at Establishment 3, show that the methods used were fairly uniform throughout, with the exception of Experiments 250 to 255, in which the drying was prolonged well beyond the period of 20 days. In the remaining 18 experiments the drying period did not exceed 23 days. In the experiments conducted at Establishment 2A (Table 17) the drying period with few exceptions was 10 days or less, but inasmuch as 4 of these experiments yielded positive results, it is quite evident that drying periods of 10 days or less are inadequate so far as concerns the destruction of trichinæ.

In Experiment 268 (Establishment 2A) a butt cured 32 days was fed immediately to 3 rats and 3 mice. The animals became infected; as indicated in the table, however, the other butts in this experiment after having been smoked and dried following curing no longer contained viable trichinæ.

Following are the post-mortem records of the test animals which became infected in the experiments at Establishment 2A:

*Experiment 257.*—Three rats fed at the laboratory of Establishment 2A became infected. Four rats fed at the Washington laboratory escaped infection. A microscopic examination of decapsuled larvæ obtained by artificial digestion of a few grams of meat from these products after shipment to Washington revealed definite degenerative changes. These pieces of capicola were cured for a period of 23 days and dried for 7 days. The period involved in the transfer of the products and delay before washing out the salt was 6 days, making in the case of the pieces examined at the Washington laboratory a total of 36 days of salt action, excluding the 45-hour smoking period.

*Experiment 258.*—Three rats fed at Establishment 2A became infected. Four rats fed in Washington developed heavy infections. The products were cured for 27 days. The drying period in this case was 4 days, and only 2 days elapsed between the end of the drying process and the first feeding at the Washington laboratory, making a total of 33 days, excluding the 35 hours of smoking.

*Experiment 259.*—Three rats fed at Establishment 2A became infected. Four rats fed in Washington developed mild infections. Four days were involved in the transfer of the products to Washton, which, added to the curing and drying periods, gives a total of 35 days, excluding the 35 hours of smoking.

*Experiment 260.*—The rats fed at Establishment 2A became infected. Four rats fed in Washington escaped infection. The difference in time of feeding was 4 days, which, added to the drying and curing periods, gives a total of 40 days of salt action in the case of the pieces examined in Washington.

These results indicate that a combined curing and drying period of 35 days or less plus the smoking period is inadequate to destroy trichinæ in these products. The results also indicate, however, that somewhat longer periods are adequate, as shown not only by the experiments at Establishment 3 in which the combined periods of curing and drying ranged from 41 to 48 days, but also by Experiments 261 to 272 at Establishment 2A in which the total period of curing and drying, excluding smoking, was between 40 and 45 days. The specifications for the preparation of this product require 25 days of curing at a temperature not lower than 36° F., 30 hours of smoking at a temperature not lower than 80° F., and 20 days of drying at a temperature not lower than 45° F.

## EXPERIMENTS WITH COPPA.

The following experiments with products known as coppa, which are similar in all respects to capicola except that smoking is omitted, were conducted at Establishments 2A and 3, as shown in Table 18. Inasmuch as smoking is omitted the experiments were planned with a view of testing a longer period of curing and drying than that employed in the case of capicola.

The records follow in Table 18.

TABLE 18.—*Experiments with coppa.*

(EXPERIMENTS 276–280 WERE PERFORMED IN ESTABLISHMENT 3, AND 281–282 IN ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Drying. | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in dry room. | Temperature. | | Time. | Temperature. | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | |
| | *Hog.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | |
| 276 | 37 | 18 | 43 | 36 | ........ | ........ | ........ | 29 | 80 | 63 | Negative. |
| 277 | 38 | 18 | 40 | 34 | ........ | ........ | ........ | 30 | 69 | 54 | Do. |
| 278 | 39 | 18 | 39 | 34 | 3 | 68 | 57 | 28 | 59 | 51 | Do. |
| 279 | 40 | 22 | 38 | 34 | 1⅝ | 64 | 59 | 28 | 58 | 53 | Do. |
| 280 | 41 and 42 | 18 | 38 | 34 | 2 | 65 | 56 | 28 | 58 | 52 | Do. |
| 281 | 38 and 39 | 17 | 38 | 33 | 2 | 73 | 62 | 30 | 59 | 43 | Do. |
| 282 | 40–42 | 17 | 38 | 35 | 2 | 58 | 56 | 27 | 62 | 46 | Do. |

The foregoing data show that the products were held in cure and in the drying room for periods varying from 46 to 52 days from the time the salt was added to the meat. Inasmuch as the data are rather limited only the maximum period has been accepted by the bureau as adequate for the destruction of trichinæ. The specifications adopted require a minimum period of curing of not less than 18 days at a temperature not lower than 36° F. to be followed by drying for at least 35 days at a temperature not lower than 45° F.

### EXPERIMENTS WITH LOCKSCHINKEN.

Forty-one experiments with lockschinken were carried out in Establishments 2A and 3, 17 tests in the former and 24 in the latter. For each experiment 4 to 6 pieces were prepared. These ranged in weight from 2 to 7½ pounds. The pork loins used in these tests were cured either by means of pickle solution alone or by means of pickle solution combined with dry salt, the dry salt with other ingredients of the curing mixture being added to the meat on the basis of 4 pounds of salt per hundredweight of meat. The pickle solutions were used in strengths ranging from 50° to 65° (salometer).

Following the application of the dry-curing mixture the meat was packed in a tierce and the pickle solution then added. During the process of curing the meat was generally overhauled and a fresh pickle solution added at certain intervals. After stuffing, the products were generally held in a drying room for a short period before being placed in smoke. After smoking, the products were in most cases dried for a number of days, as shown in the following tables:

### TABLE 19.—*Experiments with lockschinken.*

(ESTABLISHMENT 2A.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Results of tests on animals at Chicago and Washington. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in dry room. | Temperature. | | Time. | Temperature. | | Time. | Temperature. | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | |
| | *Hog.* | *Days.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | *Hours.* | °*F.* | °*F.* | *Days.* | °*F.* | °*F.* | |
| 283 | 4 to 6 | 21 | 40 | 34 | 2 | 62 | 57 | 17 | 74 | 62 | ....... | ..... | ..... | Negative. |
| 284 | 7 and 8 | 20 | 37 | 32 | 1 | ..... | ..... | 45 | 98 | 70 | ....... | ..... | ..... | Do. |
| 285 | 9 and 10 | 20 | 37 | 34 | ....... | ..... | ..... | 27½ | 85 | 70 | ....... | ..... | ..... | Positive. |
| 286 | 11 | 18 | 39 | 35 | 1 | 65 | 62 | 30 | 84 | 79 | 4 | 58 | 53 | Negative. |
| 287 | 12 and 13 | 17 | 42 | 39 | 2 | 63 | 59 | 28 | 85 | 63 | 3 | 57 | 53 | Do. |
| 288 | 14 and 15 | 18 | 43 | 36 | ¾ | 65 | 63 | 30 | 84 | 66 | 7 | 66 | 54 | Do. |
| 289 | 16 and 17 | 18 | 41 | 35 | 1¼ | 66 | 64 | 29 | 134 | 81 | ....... | ..... | ..... | Do. |
| 290 | 18 and 19 | 20 | 41 | 35 | 1 | 68 | 66 | 34 | 105 | 75 | 10 | 74 | 55 | Do. |
| 291 | 20 and 21 | 18 | 43 | 36 | 1 | 76 | 69 | 30 | 96 | 88 | 10 | 77 | 62 | Do. |
| 292 | 22 and 23 | 19 | 52 | 39 | 1 | 88 | 78 | 30 | 102 | 90 | 10 | 84 | 66 | Do. |
| 293 | 24 and 25 | 18 | 42 | 34 | 1 | 74 | 67 | 30 | 93 | 85 | 10 | 66 | 55 | Do. |
| 294 | 26 and 27 | 18 | 39 | 34 | 1 | 70 | 64 | 30 | 92 | 83 | 9 | 60 | 53 | Do. |
| 295 | 28 and 29 | 18 | 40 | 34 | 1 | 63 | 60 | 30 | 89 | 83 | 12 | 60 | 51 | Do. |
| 296 | 30 | 18 | 39 | 32 | 1⅚ | 61 | 56 | 30 | 88 | 83 | 10 | 60 | 50 | Do. |
| 297 | 31 | 18 | 41 | 33 | 1 | 65 | 63 | 30 | 92 | 81 | 9 | 58 | 51 | Do. |
| 298 | 32 and 33 | 18 | 42 | 32 | 1 | 69 | 60 | 30 | 91 | 82 | 10 | 61 | 53 | Do.[1] |
| 299 | 35 and 36 | 18 | 45 | 36 | 1⅚ | 70 | 63 | 32 | 93 | 85 | 10 | 73 | 61 | Do.[1] |

[1] At Washington; no tests at Chicago.

### TABLE 20.—*Experiments with lockschinken.*

(ESTABLISHMENT 3.)

| Experiment No. | Source of meat. | Preliminary curing. | | | | | | Smoking. | | | Drying. | | | Results of tests on animals at Chicago and Washington. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in cooler. | Temperature. | | Time in green room. | Temperature. | | Time. | Temperature. | | Time. | Temperature. | | | |
| | | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | Maximum. | Minimum. | | |
| | *Hog.* | *Dys.* | °*F.* | °*F.* | *Dys.* | °*F.* | °*F.* | *Hrs.* | °*F.* | °*F.* | *Dys.* | °*F.* | °*F.* | | |
| 300 | 5 and 6 | 21 | 41 | 36 | ..... | .... | .... | 72 | 80 | 74 | 6 | 59 | 52 | Negative | |
| 301 | 7 and 8 | 25 | 39 | 34.5 | 1 | 59.5 | 58 | 96 | 78 | 74 | 4⅙ | 60 | 47.5 | do. | |
| 302 | 9 to 11 | 18 | 37 | 34.5 | 3 | 64 | 58 | 32 | 77 | 74 | 9 | 52.5 | 44 | do. | |
| 303 | 12 | 26 | 38 | 34 | 2 | 60 | 50 | 11 | 137 | 90 | 3 | 54 | 48 | do. | |
| 304 | 13 and 14 | 18 | 39 | 34 | 1 | 60 | 58.5 | 96 | 83 | 68 | 8 | 52 | 49 | Positive | |
| 305 | 15 | 27 | 39 | 34 | 1⅙ | 64 | 52 | 52 | 93 | 83 | 4 | 57 | 48 | Negative | |
| 306 | 16 and 17 | 25 | 41 | 36 | 1½ | 63 | 61 | 12 | 135 | 87 | 9 | 77.5 | 48 | do. | |
| 307 | 18 | 19 | 44 | 35 | ⅚ | 72.5 | 72.5 | 12 | 129 | 103 | 9 | 75 | 62 | do. | |
| 308 | 19 and 20 | 26 | 43 | 36 | 1 | 78 | 72 | 12 | 128 | 101 | 9 | 84 | 69 | do. | |
| 309 | 21 and 22 | 21 | 38 | 35 | 1⅙ | 58 | 54 | 12 | 133 | 90 | 13 | 64 | 49 | do. | |
| 310 | 24 and 25 | 25 | 38 | 34 | 1⅙ | 68 | 54 | 12 | 105 | 93 | 11 | 55 | 47 | do. | |
| 311 | 26 and 27 | 25 | 38 | 34 | 1½ | 70 | 57 | 12 | 131 | 70 | 9 | 55 | 43 | do. | |
| 312 | 28 and 29 | 25 | 39 | 36 | ¾ | 70 | 64 | 12 | 132 | 90 | 10 | 50 | 46 | do. | |
| 313 | 30 and 31 | 26 | 40 | 35 | 2 | 68 | 59 | 12 | 140 | 99 | 9 | 51 | 45 | do. | |
| 314 | 32 and 33 | 25 | 40 | 35 | 2 | 62 | 49 | 12 | 129 | 90 | 10 | 64 | 47 | do. | |
| 315 | 34 and 35 | 27 | 40 | 33 | 3 | 53 | 48 | 12 | 145 | 92 | 10 | 74 | 50 | do. | |
| 316 | 36 and 37 | 26 | 41 | 34 | 1⅚ | 76 | 61 | 12 | 137 | 90 | 13 | 85 | 64 | do. | |
| 317 | 35 and 36 | 18 | 45 | 36 | 2 | 70 | 64 | 32 | 93 | 85 | 10 | 73 | 61 | do.[1] | |
| [2]318 | 6, 7, and 11. | 16 | 40.5 | 37 | ..... | .... | .... | 24 | 83.5 | 82 | 41 | 65 | 46 | do.[1] | 3 days en route. |
| [2]319 | 1, 2, 5 | 20 | 43 | 37 | ..... | .... | .... | 24 | 72 | 65 | 41 | 74 | 46 | do.[1] | 4 days en route. |
| [2]320 | 3, 4, 8 | 26 | 43 | 38 | ..... | .... | .... | 24 | 78 | 68 | 29 | 74 | 46 | Doubtful[3] | Do. |
| [2]321 | 9 and 10. | 30 | 43 | 37 | ..... | .... | .... | 48 | 77 | 60 | 30 | 74 | 46 | Negative | 3 days en route. |
| [2]322 | 13 | 27 | 43 | 37 | ..... | .... | .... | 48 | 77 | 60 | 30 | 74 | 46 | do. | Do. |
| [2]323 | 14 to 17 | 35 | 44 | 37 | ..... | .... | .... | 60 | 92 | 70 | 27 | 74 | 49 | do. | 4 days en route. |

[1] Negative at Washington; no tests at Chicago.

[2] Experiments 318 to 323 were preliminary to the other experiments in this series and the identification numbers of the hogs have reference to a different series of experimental animals.

[3] Four rats negative; a fifth rat that died 8 days after feeding was found to contain 10 intestinal trichinæ, but their condition was not noted.

An examination of the data in Tables 19 and 20 shows that with the exception of Experiment 285, Establishment 2A, and Experiment 304, Establishment 3, the results of feeding experimental animals were negative. The pieces in Experiment 285, Establishment 2A, were fed to four rats in Washington, infecting all of them, and also infected the rats fed in Chicago. The test animals were killed one month after feeding and found to be heavily infected with trichinæ. The pieces in Experiment 304, Establishment 3, also infected the rats to which portions of the meat were fed in the Washington laboratory and the mice fed in the Chicago laboratories of Establishment 3 (6 mice). The products in Experiment 285 were not dried subsequent to smoking, but those in Experiment 304 were smoked for a long period (96 hours at a temperature of 68° to 83° F.) and were then dried for 8 days after smoking.

It has been concluded that low-temperature smoking, even though it may be greatly prolonged, followed by drying, is not a reliable prophylactic measure against trichinæ in lockschinken. In experiments 306 to 316, Establishment 3, high-temperature smoking for a period of 12 hours, similar to that employed in connection with fresh summer sausage was substituted for prolonged smoking at a low temperature. Although the results from this modification of method were very satisfactory in respect to the destruction of the trichinæ, further tests have been discontinued because it was found that the high-temperature smoking rendered the products unsatisfactory from a commercial standpoint.

In view of the results of our experimental work the Bureau of Animal Industry does not recognize any curing method as adequate for the destruction of trichinæ in lockschinken, and this product may be prepared in official establishments only from pork that has been refrigerated at a temperature of not higher than 5° F. for a period of not less than 20 days in accordance with the results obtained in experiments on refrigeration recorded in a former paper (Ransom, 1916).

## THE INFLUENCE OF SALT ON THE RESISTANCE OF TRICHINA LARVÆ TO HEAT.

The experiments described below were performed in the laboratory of the Zoological Division in order to supplement the practical tests at the meat-packing establishments in Chicago, the aim being to secure data concerning the effects of preliminary curing on the resistance of trichinæ to heat. In connection with the discussion of the experiments on fresh summer sausage it was indicated that inadequate preliminary curing may vitiate the effects of subsequent smoking. The experiments described and tabulated below demonstrate this point.

The following procedure was employed: Trichinous meat was ground up in a meat chopper and mixed thoroughly with salt, which was added on the basis of 3⅓ pounds per hundred pounds of meat. The meat was then placed in a refrigerator at a temperature of about 10° to 12° C. for a certain period designated in the tables as "time in cure," after which it was stuffed in casings and made into sausages weighing between 200 and 500 grams. The sausages were then placed in an incubator for a given period designated as "time in incubator," and finally fed to rats after washing out the salt.

Table 21.—*Effects of salt on resistance of trichina larvæ to high temperatures.*

| Experiment No. | Sausage No. | Time in cure. | Time in incubator. | Temperature of incubator. |  | Results on rats. |
|---|---|---|---|---|---|---|
|  |  |  |  | Maximum. | Minimum. |  |
|  |  | *Hours.* | *Hours.* | ° *C.* | ° *C.* |  |
| 325 | 1 | 24 | 6 | 53 | 52 | 4 rats fed; all infected. |
| 326 | 2 | 48 | 6 | 53 | 51 | Do. |
| 327 | 3 | 72 | 5 | 53.5 | 51 | Do. |
| 328 | 4 | 92 | 6 | 54 | 50 | 4 rats fed; none infected. |
| 329 | 5 | 120 | 6½ | 52 | 42.5 | 2 rats fed; none infected. |
| 330 | 6 | 144 | 5 | 53.5 | 51 | 3 rats fed; none infected. |
| 331 | 7 | 144 | 5 | 53 | 48 | Do. |

In the next series of experiments the sausage was subjected to a lower incubator temperature and was held for a longer period. The data are presented in Table 22.

Table 22.—*Effect of salt on the resistance of trichina larvæ to moderate temperatures.*

| Experiment No. | Sausage No. | Time in cure. | Time in incubator. | Temperature of incubator. |  | Results on rats. |
|---|---|---|---|---|---|---|
|  |  |  |  | Maximum. | Minimum. |  |
|  |  | *Hours.* | *Hours.* | ° *C.* | ° *C.* |  |
| 332 | 1 | 25 | 18 | 43 | 41 | 3 rats fed; 2 infected; 1 not infected. |
| 333 | 2 | 49 | 18 | 44 | 43.5 | 4 rats fed; 3 infected; 1 not infected. |
| 334 | 3 | 72 | 24 | 44 | 42.5 | 4 rats fed; none infected. |
| 335 | 4 | 96 | 24 | 44 | 43 | Do. |
| 336 | 5 | 96 | 18 | 44.2 | 42 | 5 rats fed; none infected. |
| 337 | 6 | 96 | 16 | 44 | 44 | 4 rats fed; none infected. |
| 338 | 7 | 188 | 18 | 44 | 43 | Not fed to rats. Decapsuled larvæ dead. |

A third series of experiments bearing on this question was performed as follows:

Four lots of chopped-up trichinous pork were placed in an incubator at an initial temperature of 44° C., the final temperature at the end of about 3½ hours reaching 54° C. Lot No. 1 contained trichinous meat which had been subjected to a preliminary cure[1] of 48 hours; lot No. 2 contained trichinous meat which had been cured for 72 hours; lot No. 3 contained trichinous meat which had been cured for 96 hours; lot No. 4 contained trichinous meat to which no salt had been added.

---

[1] The quantity of salt used in these experiments was added on the usual basis of 3⅓ pounds of salt per hundredweight of meat.

After the meat was taken out of the incubator it was washed for 2 hours in running water and a portion from each lot was digested in an acidified solution of scale pepsin. The decapsuled larvæ were then examined to determine the effects of the exposures. The results follow:

Lot No. 1 (cured 48 hours): The larvæ were normal as to color and state of contraction and responded vigorously to heat stimulation.

Lot No. 2 (cured 72 hours): About 50 per cent of the larvæ examined responded to heat stimulation.

Lot No. 3 (cured 96 hours): Twenty-five larvæ were examined. Of these 22 were pale in appearance and uncoiled, and only 3 were tightly coiled.

Lot No. 4 (uncured): The larvæ were markedly active.

From the data presented above it is evident that the action of salt, if continued long enough, has a decided influence on the larvæ and in some manner lowers their vitality, evidenced by their loss of tolerance to certain temperatures which unsalted larvæ or larvæ that have been exposed to the action of salt for shorter periods resist without any apparent loss of vitality. An 18-hour exposure of small-sized sausages to a temperature ranging between 42° and 44° C. apparently requires a preliminary exposure to the action of salt for at least 96 hours in order to bring about the death of the parasites.

Although an exposure to heat for 16 hours also gave negative results, it was found that shorter exposures, namely, 12 or even 14 hours, resulted in infections when meat so exposed was fed to rats. A 5 or 6 hours' exposure of the meat to temperatures ranging between 50° and 54° C. also requires a preliminary salt exposure of about 96 hours' duration in order to insure the destruction of the parasites.

In view of these data it is evident that in the case of fresh summer sausage and certain other products that are not dried after smoking, the duration of preliminary curing process prior to smoking is an important factor in rendering the products innocuous.

### APPEARANCE OF DECAPSULED LARVÆ FROM SALTED PORK.

Dead larvæ in salted pork present a characteristic appearance after decapsulation by artificial digestion. They are all uncoiled, and have the appearance of the figure 6. The esophageal cell body, which has a brilliant coloration in the normal larva, has lost its color and appears pale. The tissues of the worm are shrunken and wrinkled and the germ cells as well as esophageal cells appear to be plasmolyzed. Sometimes numerous vacuoles may be seen in the larvæ, and occasionally the tissues of the worm show evidence of having been partially digested. The larvæ obtained from hams that have been dried for 10 days at a temperature of about 100° F. presented the most distorted appearance. As a matter of fact, but few larvæ can usually be obtained by the artificial digestion of relatively large quantities of ham dried in this way, although the uncured meat from the same carcasses may show a heavy infestation.

In view of the prolonged action of the salt in the case of such hams it is likely that the parasites are so thoroughly dried as a result of the withdrawal of water from their tissues that the cuticles give way in the process of digestion and the worms are thus completely destroyed. Fragments of larvæ in such digestion cultures were often noted and occasionally partly ruptured empty cuticles were found.

## SUMMARY.

The following principal conclusions are based on facts presented in the foregoing pages:

Pork products of kinds customarily eaten without cooking may be rendered safe for consumption, so far as the dangers of trichinosis are concerned, by certain curing processes. No single formula can be applied to all such products, as different ones require different treatments, depending largely on their size and on whether they are smoked.

Sausages of moderate sizes have been rendered innocuous by the admixture of salt to the meat (not less than 3⅓ pounds of salt per hundredweight of meat) followed by preliminary curing and then by drying. A minimum period of 25 days for the duration of these processes from the time the salt is added to the meat has been adopted as meeting the requirements for the destruction of trichinæ in unsmoked sausage. Of the 25 days at least 20 days must be devoted to drying at temperatures not lower than 45° F. Thus, a period of 5 days is allowed for preliminary curing, which may be curtailed, however, provided the time in the drying room is correspondingly increased.

In the case of certain sausages known as pepperoni, which are stuffed in narrow, thin casings, it was found feasible to reduce the curing period to 20 days, of which at least 15 days must be given to drying. This allows 5 days for preliminary curing, which may be curtailed provided the time in the drying room is correspondingly increased.

In the case of smoked sausage it was found feasible to reduce still further the drying period. This variety of sausage is rendered innocuous by being subjected to a preliminary cure and then smoked at temperatures ranging around 80° F. for 40 hours followed by drying for 10 days at temperatures not lower than 45° F. Including the preliminary curing period, the sausage is held under supervision for 18 days from the time the salt is added to the meat. Sausage smoked at temperatures ranging from 125° to 130° F. for a relatively brief period following a preliminary curing period of at least 6 days is rendered innocuous without subsequent drying. Specifically the smoking period lasts 12 hours, of which 4 hours are devoted to bringing the temperature up gradually to at least 128° F. During the next 4 hours the temperature is maintained at 128° F. or higher, and during the remaining 4 hours it is allowed to go down gradually to a point not below 90° F.

Sausage smoked for 6 hours at a temperature of about 100° F. followed by 10 days of drying was not rendered innocuous. This procedure is accordingly not recognized by the bureau as meeting requirements for the destruction of trichinæ in sausage.

Hams are rendered innocuous by the following methods: (1) The products are cured by means of dry salt (4 pounds of salt per hundredweight of meat) for at least 40 days at a temperature not lower than 36° F., and then smoked or pale-dried for 10 days at a temperature not lower than 95° F.; or (2) the products are cured on the basis of 3 days' cure for each pound of weight of individual hams, followed by 48 hours of smoking at a temperature not lower than 80° F. and finally by 20 days' drying at a temperature not lower than 45° F.

Products known as coppa are rendered innocuous by dry-salt curing for 18 days (4½ pounds of salt per hundredweight of meat with the addition of small quantities of pickle solution) at temperatures not lower than 36° F. followed by drying for at least 35 days at a temperature not lower than 45° F.

Products known as capicola are rendered innocuous by 25 days of curing under conditions similar to those used in preparing coppa, followed by 20 hours of smoking at a temperature not lower than 80° F., and finally by 20 days' drying at a temperature not lower than 45° F.

No method has yet been discovered for rendering lockschinken innocuous by means of curing without affecting the quality of the product.

The factors which appear to exert injurious influences on trichinæ in the course of curing are salt and temperature. The former gradually undermines the vitality of the parasites, probably by withdrawing water from their tissues and also perhaps by exerting upon them a direct toxic action. Salt furthermore lowers the resistance of the larvæ to heat and thus renders them susceptible to temperatures which normally would not prove fatal. The temperatures employed during smoking or pale-drying in most of these experiments were by themselves too low to injure seriously the parasites, but the combined action of salt and temperature was efficacious in destroying the vitality of the larvæ.

Drying is also a decided factor in bringing about the destruction of trichinæ, apparently because the evaporation of moisture from the meat increases the concentration of the salt in addition to other possible injurious effects which it may exert.

## REFERENCES TO LITERATURE CITED.

Blanchard, Raphaël.
1888.—Traité de zoologie médicale. v. 1: Protozoaires, histoire de l'œuf, cœlentérés, échinodermes, vers (aneuriens, plathelminthes, némathelminthes). Fasc. 3, pp. 481–808, figs. 272–387. 8°. Paris. [Issued Nov. 1.]

Colin, Gabriel Constans.
1882.—Sur les trichines dans les salaisons <Compt. rend. Acad. d. sc., Par., v. 94 (13), 27 mars, pp. 886–888.

Fourment, L.
1882.—Sur la vitalité des trichines enkystées dans les viandes salées <Compt. rend. Acad. d. sc., Par., v. 94 (17), 24 avril, pp. 1211–1213.

Fürstenberg, Moritz H. F.
1864.—Untersuchungen über den Einfluss der Fütterung trichinenhaltigen Fleisches bei Hausthieren <Ann. d. Landwirthsch. in d. k. preuss. Staat., Wchnbl., Berl., v. 4 (30), 20. Juli, pp. 275–276; (31), 27. Juli, pp. 283–286.

Haubner, Gottlieb Carl.
1864.—Ueber die Trichinen, mit besonderer Berücksichtigung der Schutzmittel gegen die Trichinenkrankheit beim Menschen <Mag. f. d. ges. Thierh., Berl., v. 30 (2), pp. 129–176, pl. 2, figs. 1–6.

Haubner, Gottlieb Carl; Leisering, August Gottlob Theodor; and Küchenmeister, Friedrich.
1863.—Versuche mit Trichinen <Ber. ü. d. Veterinärw. im Königr. Sachs., Dresd. (1862), pp. 114–120.

Leuckart, Karl Georg Friedrich Rudolph.
1876.—Die menschlichen Parasiten und die von ihnen herrührenden Krankheiten. v. 2, 3. Lief., pp. 513–882, 119 figs. 8°. Leipzig.

Ransom, Brayton H.
1916.—Effects of refrigeration upon the larvæ of *Trichinella spiralis* <J. Agric. Research, Dept. Agric., Wash., v. 5 (18), Jan. 31, pp. 819–854.

Ransom, Brayton H., and Schwartz, Benjamin.
1919.—Effects of heat on trichinæ <J. Agric. Research, Dept. Agric., Wash., v. 17 (5), Aug. 15, pp. 201–221.

Stiles, Ch. Wardell.
1898.—The flukes and tapeworms of cattle, sheep, and swine, with special reference to the inspection of meats. (*In* The inspection of meats for animal parasites) <Bull. 19, Bureau Animal Indust., U. S. Dept. Agric., Wash., Feb. 8, pp. 11–136, figs. 1–124.

Virchow, Rudolf Ludwig Carl.
1866.—Die Lehre von den Trichinen mit Rücksicht auf die dadurch gebotenen Vorsichtsmassregeln für Laien und Aerzte dargestellt. 3. erheblich vermehrte und umgearbeitete Aufl. 86 pp., 1 l., 7 figs., 1 pl., 5 figs. 8° Berlin.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
△